Grayling I Site Characterization and Data Summary

Charles D. Hahn and
Thomas E. Berry

U.S. Army Engineer Waterways
Experiment Station
Vicksburg, MS

SWOE Report 93-2
December 1993

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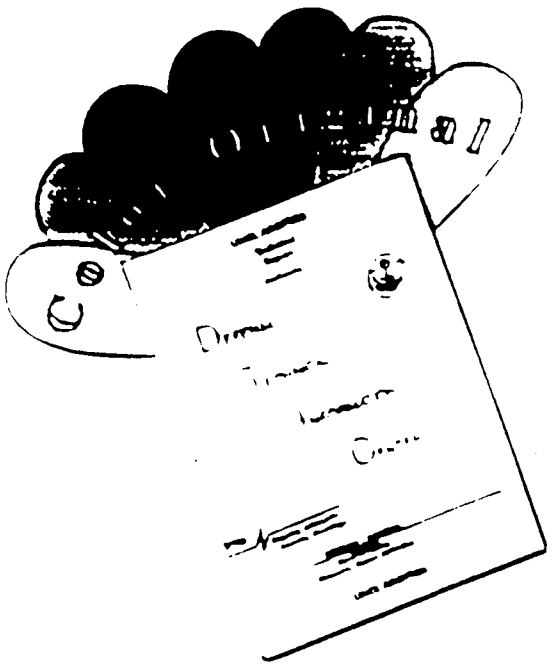

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FOREWORD

SWOE Report 93-2, December 1993, was prepared by C.D. Hahn and T.E. Berry of U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

This report is a contribution to the Smart Weapons Operability Enhancement (SWOE) Program. SWOE is a coordinated, Army, Navy, Marine Corps, Air Force and ARPA program initiated to enhance performance of future smart weapon systems through an integrated process of applying knowledge of the broadest possible range of battlefield conditions.

Performance of smart weapons can vary widely, depending on the environment in which the systems operate. Temporal and spatial dynamics significantly impact weapon performance. Testing of developmental weapon systems has been limited to a few selected combinations of targets and environmental conditions, primarily because of the high costs of full-scale field tests and limited access to the areas or events for which performance data are required.

Performance predictions are needed for a broad range of battlefield environmental conditions and targets. Meeting this need takes advantage of significant DoD investments by Army, Navy, Marine Corps and Air Force in 1) basic and applied environmental research, data collection, analysis, modeling and rendering capabilities, 2) extensive target measurement capabilities and geometry models, and 3) currently available computational capabilities. The SWOE program takes advantage of these DoD investments to produce an integrated process, the SWOE Process.

SWOE is developing, validating, and demonstrating the capability of the SWOE Process to handle complex target and environment interactions for a broad range of battlefield conditions. SWOE is providing the DoD smart weapons and autonomous target recognition (ATR) communities with a validated capability to integrate measurements, information bases, modeling, and simulation techniques for complex environments. This is a DoD-wide partnership that works in concert with advanced weapon system developers and major weapon system test and evaluation programs.

The SWOE program started in FY89 under Balanced Technology Initiative (BTI) sponsorship. Present sponsorship is by the U.S. Army Corps of Engineers (lead service), the individual services, and the Joint Test and Evaluation (JT&E) program of the Office of the Director of Test & Evaluation, Office of the Under Secretary of Defense OUSD(A/DT&E).

The Joint Test Director is Dr. J.P. Welsh. The Deputy Test Directors are: (Army) LTC Jerre Wilson and (Air Force) Maj Richard Jennings. The Integration Manager is Mr. Richard Palmer. The Modeling Configuration Manager is Dr. George G. Koenig.

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13. ABSTRACT *(Maximum 200 words)*

The purpose of the Smart Weapons Operability Enhancement (SWOE) Joint Test and Evaluation Program is to validate the SWOE scene generation procedure. Once validated, this procedure will hopefully change the design-test-redesign approach to smart weapons development, test, and evaluation. Using the SWOE process, smart weapons designers will be able to evaluate their sensor algorithms on simulated scenes with a greater degree of variability than is often presented during the test phase of the design process. The SWOE process will also allow for the smart weapon designs to be evaluated for different environments without the need for expensive and time-consuming data collection exercises.

This report describes the site of the SWOE Grayling 1 data collection exercise, the data collection plans and techniques used, and the data collected. The data collection period covered 41 days from 15 September to 25 October 1992, and this report presents the meteorological, thermal, infrared, and other environmental data collected by the U.S. Army Engineer Waterways Experiment Station.

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Contents

Preface

The data collection activities reported herein were conducted by the U.S. Army Engineer Waterways Experiment Station (WES) to characterize the site and scene conditions during the Smart Weapons Operability Enhancement (SWOE) Joint Test and Evaluation (JT&E) Grayling 1 exercise conducted at Grayling, MI, from 15 September to 25 October 1992. It was funded by the Department of Defense SWOE JT&E Program Office, Hanover, NH. Dr. J. Pat Welsh was the Joint Test Director.

WES has prepared three related reports in support of the Grayling 1 exercise for the SWOE JT&E Program. These are as follows:

a. "Grayling 1 Information Base for Generation of Synthetic Thermal Scenes"

b. "Grayling 1 Site Characterization and Data Summary"

c. "Analysis of Thermal Imagery Collected at Grayling 1, Grayling, Michigan"

This study was conducted under the general supervision of Dr. John Harrison, Director, Environmental Laboratory (EL), WES, and Mr. H. Roger Hamilton, Acting Chief, Natural Resources Division (NRD), EL, and Mr. Harold W. West, Chief, Environmental Characterization Branch (ECB), NRD, and under the direct supervision of Mr. Charles D. Hahn, WES project coordinator.

Messrs. Hahn and Thomas E. Berry, ECB, prepared this report. Field support was provided by Messrs. Salvador Rivera, Jr., Marvin J. Wooley, David Leese, Clarence Currie, Alfonzo Vasquez, Jerrell R. Ballard, and Stephen Pranger.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

1 Introduction

The Smart Weapons Operability Enhancement (SWOE) Joint Test and Evaluation (JT&E) Program is a coordinated multiservice effort to address problems related to smart weapon system development, test, and evaluation (DT&E) in the worldwide range of battlefield environment conditions. The thrust of the Grayling 1 field exercise was to collect environmental data necessary to generate the various synthetic thermal scenes and to collect thermal image data for use in the "validation" of the SWOE thermal scene generation procedure.

Background

Future smart weapons systems will be forced to become more "autonomous" because of the reduced manpower available on the modern battlefield. The typical approach to developing smart weapons has been the test-fix-test methodology for the test and evaluation phases of development. Tests or technology demonstrations are scheduled, and the proposed system is thoroughly tested under existing environmental conditions. The results, however, may not be similar if the environmental conditions are changed. Also, the cost of this type of testing is extremely high. The primary thrust of the SWOE JT&E Program is to produce thermal scenes that accurately model the environmental conditions and the sensor that can then be input to the sensor logic to produce results comparable to those from a full-scale demonstration, all at a much lower cost. An added benefit of this procedure allows the environmental conditions to be changed so that the sensor logic may be evaluated over a variety of background conditions quickly and efficiently.

Objective

The objective of this report is to describe the procedures used to collect infrared, meteorological, environmental, and terrain data at Grayling, MI, in support of the Grayling 1 SWOE JT&E Program and to provide an inventory of the data collected.

Scope

The purpose of this report is to describe all of the data types collected by the U.S. Army Engineer Waterways Experiment Station (WES) during the Grayling 1 field data collection exercise as well as the procedures used to collect the data. The scope of this report is limited to data collected. Analysis of the data is presented in another report.[1]

1 Rivera, S., Jr. (1994). "Analysis of thermal imagery collected at Grayling 1, Grayling, Michigan," Technical Report prepared by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, for the Smart Weapons Operability Enhancement Joint Test and Evaluation Program Office, Hanover, NH.

2 Data Collection Program

Types of Data Collected

WES was responsible for collecting various types of data during the Grayling 1 data collection exercise, which was conducted from 15 September to 25 October 1992. These data included meteorological, thermal, soil moisture, and other types of physical data. WES collected thermal image data in both the short wave bands (SWB) (3 to 5 μm) and the long wave band (LWB) (8 to 12 μm). Each of the data types is described below.

Thermal data

WES also collected two types of temperature data for the SWOE JT&E program. WES positioned two thermistor arrays (Figures 1-2) in the designated imaging area (SWOE Site E) (see Figure 3) and two infrared noncontact thermometer (staring radiometer) arrays (Figures 4-5) at Site D. These arrays are further described below.

Thermistor data. Two thermistor arrays were positioned within Site E (Figure 3). Each consisted of 16 thermistors placed, using a random walk procedure, to determine xy locations and inserted just below ground level (approximately 1-cm depth). The random walk procedure consisted of generating two series of random numbers: (a) sixteen 3-digit numbers for compass direction and (b) sixteen 2-digit numbers corresponding to distance. The two series of random numbers were provided by the SWOE JT&E test director. These arrays were programmed to collect and store data using a 1-min sampling interval. Data were stored in an SM64 storage module and were collected daily by WES personnel. Specifications of the thermistors are included in Table 1.

Staring radiometer data. Two staring radiometer arrays were positioned within Site D (Universal Transverse Mercator (UTM) Coordinates 687377 E 4952448 N) (Figure 3). Each consisted of eight staring radiometers positioned to measure the apparent surface temperature of different terrain types. The staring radiometers measure reflected and radiated infrared energy in the 8- to 12-μm band and output the data for surface

Table 1
Description of Instrumentation

Measurement	Sensor	Range	Accuracy
Air temperature	Phys-Chem. Mod. 207	-33 to 48 °C	<0.1 °C
Relative humidity	Phys-Chem. Mod. 207	10 to 95%	±2%
Barometric pressure	Kavlico Barometer	0 to 15 psi	±1%
Temperature (soil)	Phys-Chem. Mod. 107	-33 to 48 °C	<0.1 °C
Wind speed	Met-One 14A	0 to 60 m/sec	±2%
Wind direction	Met-One 024A	0 to 356 deg	±1 deg
Rainfall	TE525	N/A	0.01 in.
Solar radiation	Lycor LI-200SB	0 to 1,000 W/m*m	
Apparent temperature	Model 4000A	-10 to 50 °C	±0.5 °C

temperatures. These instrumented arrays were programmed to collect 5-min averaged samples and transmit (telemeter) the data to the WES field data collection facility each hour. Specifications of the staring radiometers are listed in Table 1.

Meteorological data

WES used two automatic weather stations during the SWOE data collection period. Each station (Figure 6) was configured to collect air temperature, relative humidity, barometric pressure, wind speed, wind direction, and solar radiation. One data collection station, positioned at SWOE Site D (Figure 3), collected soil temperature at depths of 5 and 15 cm in addition to the above mentioned items. The second weather station, positioned at SWOE Site H (690591 E 4953418 N), was located on top of a small building (Figure 7) to collect precipitation data. These stations were programmed to sample at 1-min intervals and transmit the data to the WES field data collection facility each hour. Table 1 describes the sensor instruments used and their specifications.

Soil data

WES collected soil moisture data at several sites using the Troxler Model 4640 Thin Layer Density Gauge and the Soiltest Speedy Moisture Gauge. The Troxler device determines soil moisture by measuring the backscattering of low-level radiation from the surface of the soil. The

amount of radiation "reflected" to the device is proportional to the moisture content of the soil. The Soiltest Speedy Moisture Gauge determines the moisture by combining a measured amount of soil with a measured amount of calcium carbide. The moisture in the soil reacts with the calcium carbide to produce acetylene gas. A pressure gauge on the Speedy then reads the gas pressure; and the reading is converted to a percent moisture. An important distinction between these two instruments is that the Troxler measures the moisture in a very thin layer at or very near the surface, while the Speedy determines the moisture based on a specific volume of soil. Speedy soil samples were collected from the area measured with the Troxler device within the 0- to 1-cm depth layer. WES also collected soil samples from each of the soil moisture areas. These are described in more detail in the following paragraphs.

Soil moisture data. A random procedure walk procedure (same procedure described above—random numbers series for direction and distance) was used to select sampling sites for measuring soil moisture. The sampling location was chosen by pacing the predetermined random number of paces along the predetermined random compass bearing. The two series of random numbers for paces and for compass bearings were provided to WES personnel by the Joint Test Directorate (JTD). Vegetation was cleared from the soil, and a moisture sample collected using the Troxler. Surface samples were also collected to be measured later. After all sites had been visited, WES personnel returned to the data collection facility and performed the moisture measurements using the Speedy. The Cold Regions Research and Engineering Laboratory (CRREL) personnel also collected volume samples from different locations for determination of soil moisture using an oven-drying technique. Two samples were collected daily at each SWOE site (Sites C (687624E 4951670N), D, E1 (687238E 4951981N), E2 (687280E 4951946N), F (687926E 4952672N), and G (687808E 4952290N)) (see Figure 3). The specifications for the Troxler Model 4640 Thin Layer Density Gauge and the Speedy Moisture Gauge are listed in Table 1.

Soil samples. Personnel also collected bulk soil samples from each SWOE site (Sites C, D, E1, E2, F, and G) and returned them for analysis by the WES Geotechnical Laboratory. Soil classification, sieve analysis, and Atterburg limits were performed on each sample.

Image data

Calibrated thermal imagery was collected using WES infrared (IR) scanners in the two primary bands, 3- to 5-μm and 8- to 12-μm, and color visual imagery. Image data were collected according to the random sampling plan for the 41-day field exercise. WES scanners were mounted on a remote-controlled pan and tilt mount atop a 55-ft boom on the WES boom truck

(Figure 8).[1] The imaging procedure followed was to first image the Eglin active blackbodies for quality control on instrument calibration by rotating the boom and cameras to point at a set of four active blackbodies (mounted in a trailer) provided by Eglin Air Force Base (AFB) and collect image data for each band. Then the boom was extended to its full height, and the scanners were rotated to measure the designated Site E1 and E2 scene area (Figure 9). Images were collected at 1-sec intervals for a period of 10 sec. These imaging periods were conducted at 5-min intervals throughout the established 2-hr sampling period. At the end of the sampling period, the boom and the scanners were repositioned to again image the active blackbodies. The imaging periods were coordinated to coincide with the passes of the airborne systems (either the Eglin AFB Airborne Seeker Evaluation System (ASETS) aircraft or the Eglin AFB Beam Approach Seeker Evaluation System (BASES) aircraft). Coordination was accomplished by ground controllers who monitored the aircraft position and coordinated the specific synchronized time image collection periods with aircraft passes over the designated standard sites. Chicken Little Project Office (CLPO) personnel performed the ground controller function.

Short wave thermal data. Short wave band (3- to 5-μm) (SWB) imagery data were collected using the Agema 870 thermal scanner (Figure 10). This scanner provided calibrated imagery of a scene in the 3- to 5-μm band. WES image data can either be digitized in real time using the Agema CATS system or be stored on video tape and digitized later. For the Grayling 1 data collection effort, the image data were stored on video tape for digitizing at the end of each mission.

Long wave thermal data. Long wave band (8- to 12-μm) (LWB) image data were collected using the Agema 782 thermal scanner (Figure 11). This scanner provided calibrated imagery of the Grayling 1 Site E scene in the 8- to 12-μm band. For the Grayling 1 effort, the imagery were digitized in real time and a video tape recorded for backup purposes.

Terrain data. Other types of data collected by WES included precision survey data to determine the locations of all ground-based electro optic measurement systems and other instrumentation locations in the high spatial resolution Site E area and to register these systems into the SWOE Grayling 1 Infobase. Additional survey data were also collected to verify the elevation and feature data in the preliminary digital data set of the test area. Data included topographic elevation data as well as the tree locations within Site E. WES used Global Positioning System (GPS) survey techniques, which included the use of Trimble 4000 SST dual frequency GPS receivers (Figure 12) to establish local ground control points as well as survey the locations of the instrumentation and other terrain and test-related features. The Trimble Pathfinder (Figure 13) was used to determine the locations of the trees and roads in the test area. WES employed

[1] To convert feet to meters, multiply number of feet by 0.3048.

a Wild T1000 electronic theodolite with a Wild DI3000 laser range finder (Figure 14) to survey approximately 200 points to enhance the 4-m topographic elevation data set.[1] WES also collected topographic surface roughness data at four locations within Site E.

Summary and Transfer of Data

Environmental and image data

All of the environmental data (meteorological and thermal data) were sorted into daily files that were then quickly examined to verify the integrity of the data through graphical display. The files were subsequently stored on floppy disk to transfer to the SWOE/JT&E field data manager for quality control. A "critical frame" was selected from all of the image data collected during a mission using a random number process. This "critical frame" image data were also quickly examined visually to ensure the quality of the image data and then stored on the same floppy disk as the environmental data. This disk was also submitted to CLPO personnel for inclusion in the Target and Background Information Library System (TABILS) database.

Soil data

Soil moisture data were recorded on worksheets as the measurements were made. Two copies of these worksheets were kept. SWOE personnel collected these worksheets for copying and entering into the SWOE soils data set; worksheets were then returned to WES personnel. The soil analysis data were included in the final Grayling database prepared at WES at the conclusion of the exercise. The Grayling database is available from WES on several standard forms.

Terrain data

The terrain data collected were processed both in the field and at WES. As these data completed final processing, they were submitted for inclusion in the final Grayling database. A more complete discussion of the terrain data and the terrain databases developed is included in another report.[1]

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1 Ballard, J. (1994). "Grayling 1 information base for generation of synthetic thermal scenes," Technical Report prepared by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, for the Smart Weapons Operability Enhancement Joint Test and Evaluation Program Office, Hanover, NH.

3 Data Presentation

During the Grayling 1 exercise, WES collected 41 days of data at several sites, which included meteorological data at 1-min intervals at Site D and H, thermal data at 1-min intervals at Sites E1 and E2, and apparent temperature data at 5-min intervals using two arrays at Site D. Approximately 50,000 thermal images were also collected in the 8- to 12-μm and 3- to 5-μm bands during the collection period (15 September - 25 October 1992). WES also collected soil moisture data at each of six sites (see Figure 3) using both the Troxler Model 4640 Thin Layer Density Gauge and the Soiltest Speedy Moisture Gauge. Also collected was a large variety of survey data for use in developing and refining the terrain database.

Meteorological Data

A large variety of meteorological conditions was encountered during the Grayling 1 data collection period. Weather conditions ranged from bright sunny days all the way through rainy days, and later in the period, snowy conditions. At Site D, the air temperature ranged from an overall low of -5.15 °C to a high of 26.73 °C with an average temperature of 9.04 °C. Relative humidity varied from 35.92 to 100 percent with an average of 88.13 percent. Barometric pressure at Site D was recorded and reported; however, at the end of the data collection period, this sensor was found to be out of calibration, and the data were not used for generation purposes. Soil temperature at Site D ranged from 3.6 to 24.1 °C with an average of 13.2 °C at a depth of 15 cm. At 5 cm, the soil temperature ranged from 1.42 to 24.53 °C with an average temperature of 12.01 °C. The wind speed ranged from 0 (calm) to 8.91 m/sec with an average wind speed of 2.11 m/sec. Plots of the daily maximum, minimum, and mean air temperatures, relative humidity, barometric pressure, solar radiation, and wind speed are shown in Figures 15-19. At Site H, the conditions were similar. The air temperature ranged from 3.9 to 25.49 °C with an average temperature of 9.28 °C. The relative humidity ranged from 25.34 to 100 percent with an average of 81.81 percent. The barometric pressure at Site H ranged from 28.18 to 30.97 in. of Hg with an average pressure of 28.64 in. of Hg. Wind speed ranged from 0 (calm) to 14.86 m/sec with an average wind speed of 3.52 m/sec. Site H was not instrumented to measure

soil temperature. Total rainfall (snow not included) at Site H was 17.82 in. Data from each of these weather stations were compiled into a daily summary chart. Examples of these data charts are included in Figures 20 and 21. A complete set of data charts is included in Appendix A.

Thermal Data

A wide variety of thermal conditions was also encountered during the Grayling 1 exercise. WES used two thermistor arrays placed in Site E and two staring radiometer arrays placed in Site D to monitor and document the thermal conditions in these areas.

Thermistor Data

WES also monitored thermal conditions at two locations in Site E. Sixteen thermistors were placed at random locations (similar to the random locations used for the soil moisture monitoring) just under the soil surface at two locations. At Site E1, the background temperatures ranged from 1.65 to 30.94 °C. The variation of temperatures encountered at this site ranged from 0.16 °C separation (difference between the 16 thermistors) to 6.74 °C separation with an average separation of 2.71 °C (calculated as maximum difference between sensor reading at a specific time). At Site E2, the background temperatures ranged from 0 to 25.79 °C. The variation of temperatures encountered ranged from 0.39 to 3.02 °C with an average variation of 3.18 °C. These data were also compiled to produce a 24-hr summary of the thermal conditions. An example of this summary is included in Figure 22. A full set of these summaries is included in Appendix A. Photographs of the terrain in which the thermistors were placed are included in Appendix B.

Staring Radiometer Data

Two staring radiometer arrays were positioned at Site D to monitor the apparent temperatures of various features in this area. Tables 2 and 3 present the range of conditions encountered as well as the features monitored. These data were also compiled to produce a 24-hr summary plot. An example of this plot is shown in Figure 23. A full set of these summaries is included in Appendix A. Photographs of features measured using the staring radiometers are included in Appendix B.

Table 2
Staring Radiometer Array 1

Channel	Description	Maximum	Minimum	Mean
1	Scrub oak	27.96	-6.52	8.58
2	Mixed vegetation	32.38	-7.16	8.86
3	Oval leaf bush	29.88	-7.95	8.89
4	Sand 1	33.70	-7.32	9.23
5	Sand 2	34.88	-7.52	9.39
6	Wide blade grass	29.22	-6.81	8.72
7	Grassy mix	32.67	-6.86	9.78
8	Mossy soil	40.09	-8.03	10.50

Table 3
Staring Radiometer Array 2

Channel	Description	Maximum	Minimum	Mean
1	Unshaded sand	34.72	-6.64	9.50
2	Partly shaded sand	35.27	-9.01	7.53
3	East tree trunk	44.11	-10.03	10.69
4	South tree trunk	37.99	-4.71	10.63
5	West tree trunk	29.47	-10.66	9.60
6	Short scrub oak	28.07	-6.96	8.90
7	Grassy sand	33.86	-7.23	9.47
8	Grassy fern	28.78	-5.83	8.94

Soil Data

WES collected soil moisture data from two locations in each of the sites (Sites C, D, E1, E2, F, and G) using the Troxler 4640 Thin Layer Density Gauge and the Soiltest Speedy Moisture Gauge. On 18 October 1992, use of the Troxler was discontinued because of the concern that the wet sand may interfere with the operation of the safety mechanisms in the Troxler and that radiation exposure may occur. At Site C, the Speedy Moisture Gauge measured moisture from 4 percent to in excess of 40 percent, and the Troxler measured moisture ranging from 4.9 to 39.6 percent.

At Site D, the Speedy results ranged from 1 to 32 percent; the Troxler results ranged from 3.9 to 18.6 percent. At Site E1, the results were 0 to 28 percent and 3.5 to 18 percent for the Speedy and Troxler, respectively. At Site E2, the moisture ranged from 2 to 31 percent and 5.9 to 19 percent for the Speedy and the Troxler. At Site F, the Speedy moisture results varied between 2 percent and in excess of 40 percent, while the Troxler results ranged from 4.4 to 23.8 percent. At Site G, the moisture results ranged from 5 to in excess of 40 percent using the Speedy and from 6.3 to 35.8 percent using the Troxler. The varied results from each of these two methods are indicative of the different sampling methods used by the two devices and the period since the most recent of the frequent rains in the area. All of the soil moisture data are included in Appendix C. Soil analysis performed at WES Geotechnical Laboratory revealed that the soils in the test area were primarily dark gray silty sands (SP-SM). The grain size results show 90 percent of the particles ranging between 0.01 and 0.5 mm. The results of the analysis are included in Appendix C.

Image Data

During the SWOE Grayling 1 effort, WES collected approximately 50,000 thermal images in both thermal bands. In addition, WES recorded over 80 hr of visual videotape during the daylight missions to aid in documenting the environmental conditions during the imaging mission. Prior to each mission, temperature-controlled blackbody sources were imaged for quality control of the calibration data. During the mission, the WES scanners were aimed at a pair of large trees near the center of the Environmental Area. The approximate geometry was an azimuth of 76°58′55″, a depression angle of 9°47′53″, and a slant range of 147.9 m to center of the field of view (FOV) from the WES sensor position located 17.2 m above ground level at coordinates 687083E 4951896N. The WES scanners were equipped with 20-deg FOV lenses, and the video camera was as closely matched to this FOV as possible. Sample images are included in Figures 24 and 25. For the Grayling 1 effort, 107 2-hr missions were scheduled; the schedule is shown in Figure 26. Of these missions, 20 were scheduled for simultaneous aircraft imagery. One mission was cancelled early in the program because of thundershowers in the area. A complete analysis of the image data is included in another report.[1]

1 Rivera, S., Jr. (1994). "Analysis of thermal imagery collected at Grayling 1, Grayling, Michigan," Technical Report prepared by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, for the Smart Weapons Operability Enhancement Joint Test and Evaluation Program Office, Hanover, NH.

Other Data Collected

Other collected data included precision survey data of instrumentation, sensor locations, and other points of interest within the test area. Location data for the scattered trees in the Site E and for selected trees in other areas (Sites C and D) were also collected, as well as a detailed characterization of each tree. The roads in the area were mapped for checks and verification of the Grayling database. Approximately 200 elevation points were surveyed for use in characterizing the microgeometry within the standard scene area (Site E). The survey data are included in Appendix D. WES collected surface roughness data at four locations (Figures 27-30) in the Environmental Area. These data are presented in Appendix E.

4 Summary

WES collected a variety of environmental data during the SWOE JT&E Grayling 1 data collection effort. The principal data collected were the thermal image data; WES collected approximately 50,000 thermal images (8- to 12- and 3- to 5-μm wave bands) of the Site E area. In addition, WES collected meteorological and thermal data from selected areas within the Grayling area, as well as detailed physical information about the area including soils, trees (geometry and location), instrument location, and elevation data. WES assisted other organizations such as CRREL, U.S. Army Atmospheric Science Laboratory, Battle Effects Division (now the Army Research Laboratory), and the CLPO in achieving a successful SWOE Grayling 1 data collection effort.

Figure 1. Thermistor Array E1

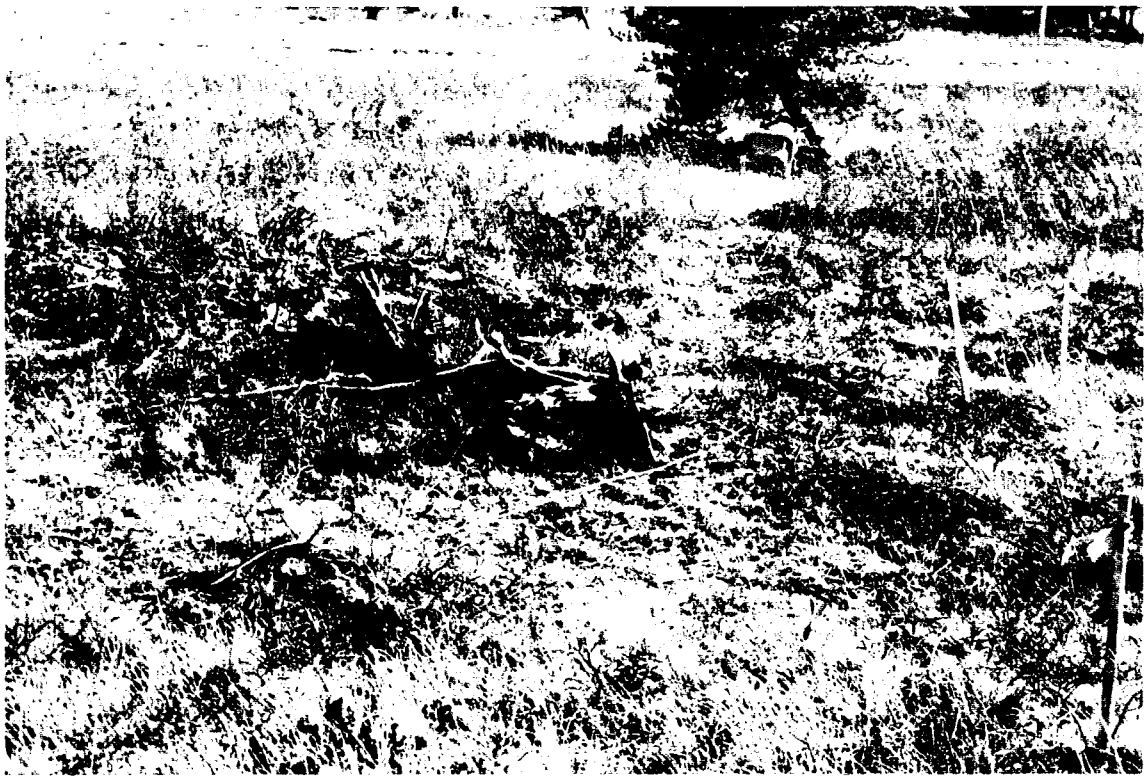


Figure 2. Thermistor Array E2

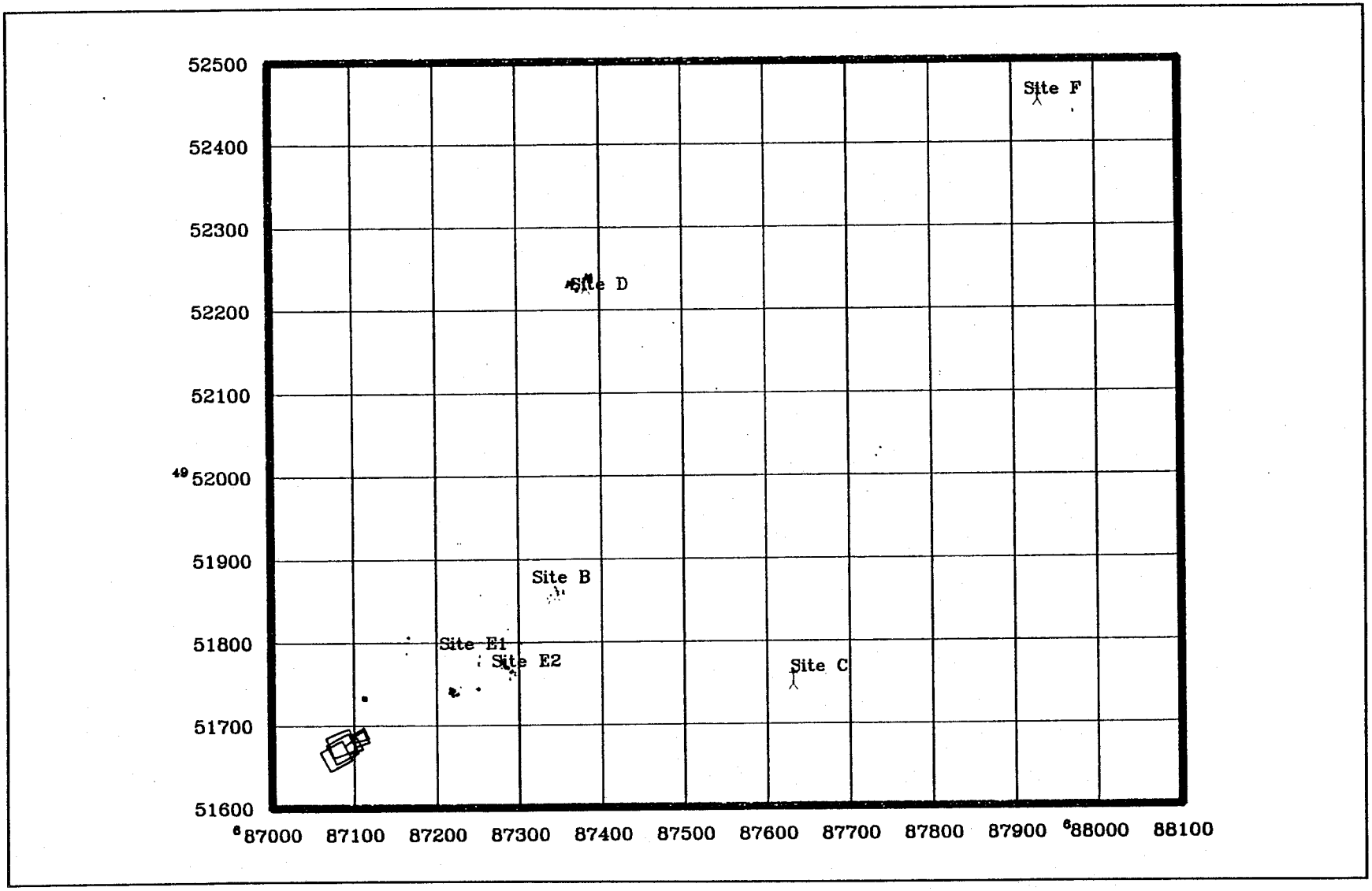


Figure 3. Site layout for Grayling 1 data collection

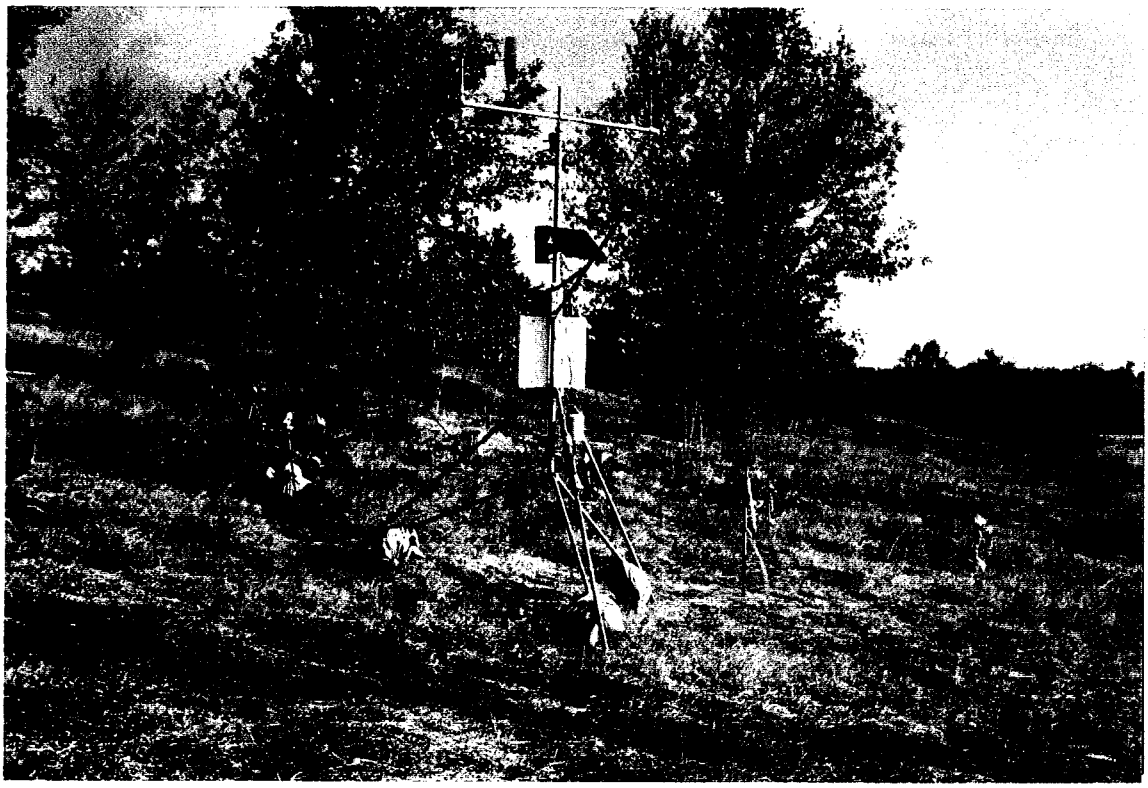


Figure 4. Staring radiometer Array D1

Figure 5. Staring radiometer Array D2

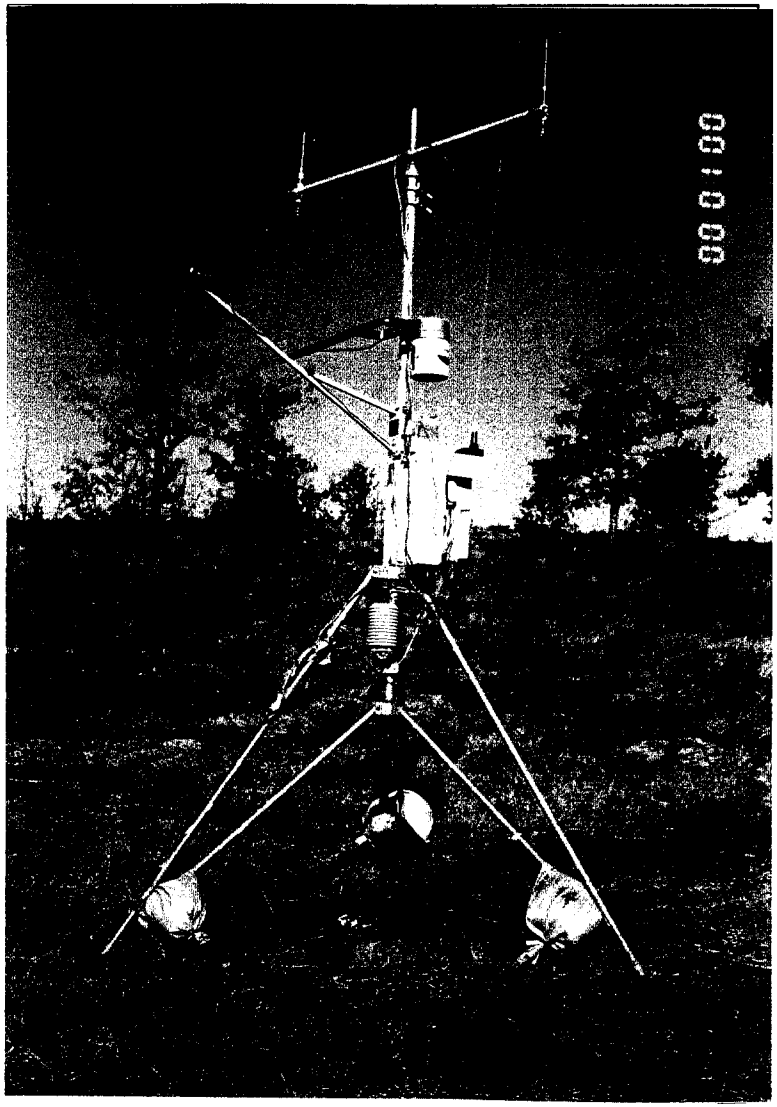


Figure 6. Weather station at Site D

Figure 7. Weather station at Site H

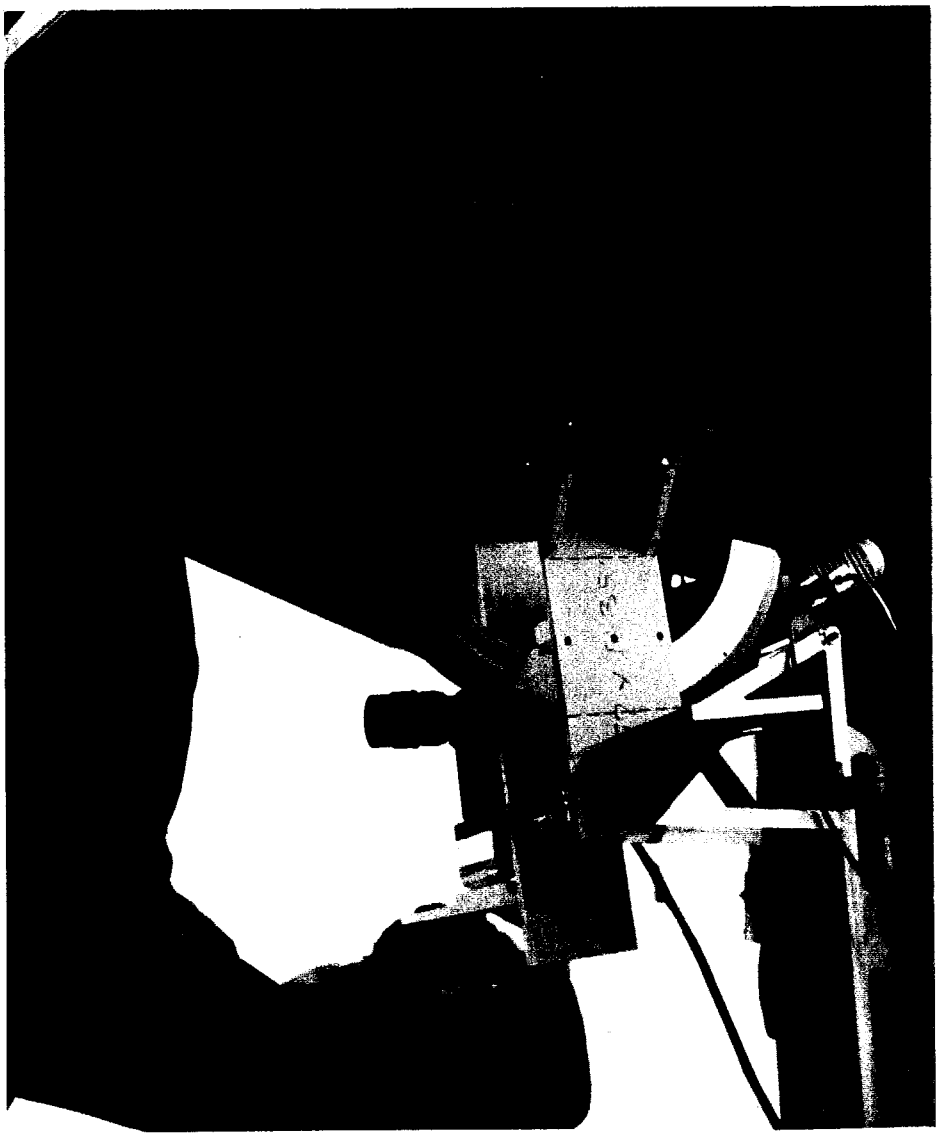


Figure 8. WES remote-controlled camera mount

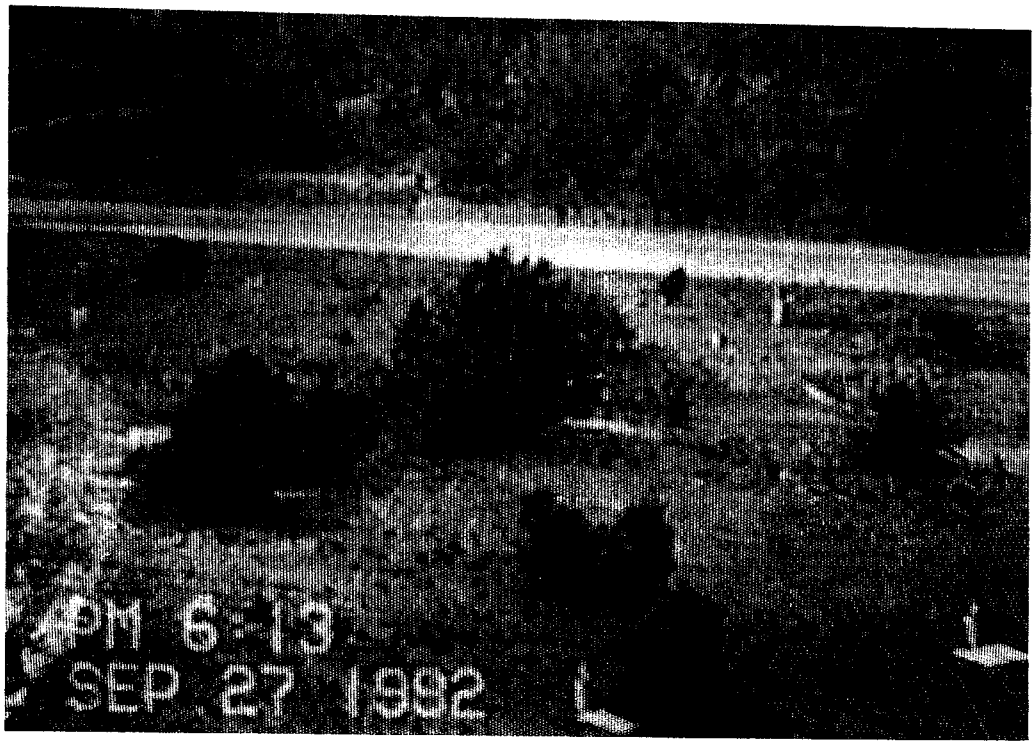


Figure 9. Site E, Grayling 1

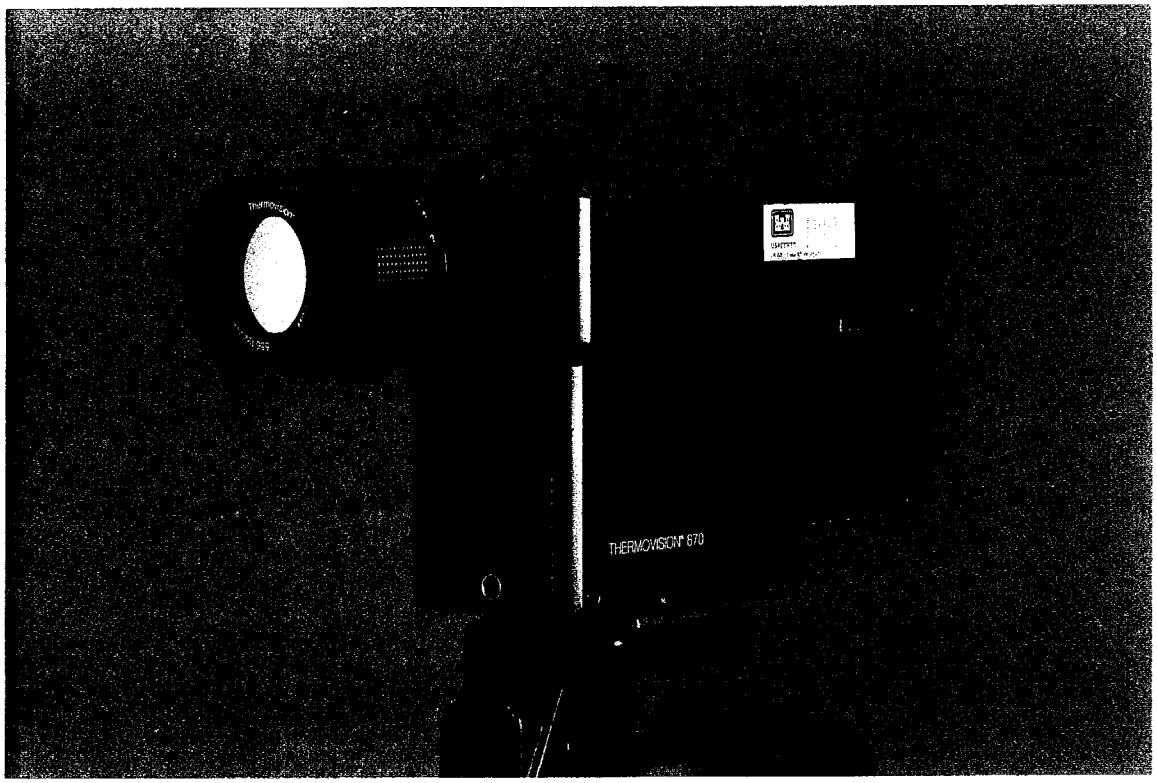


Figure 10. Agema 870 thermal scanner

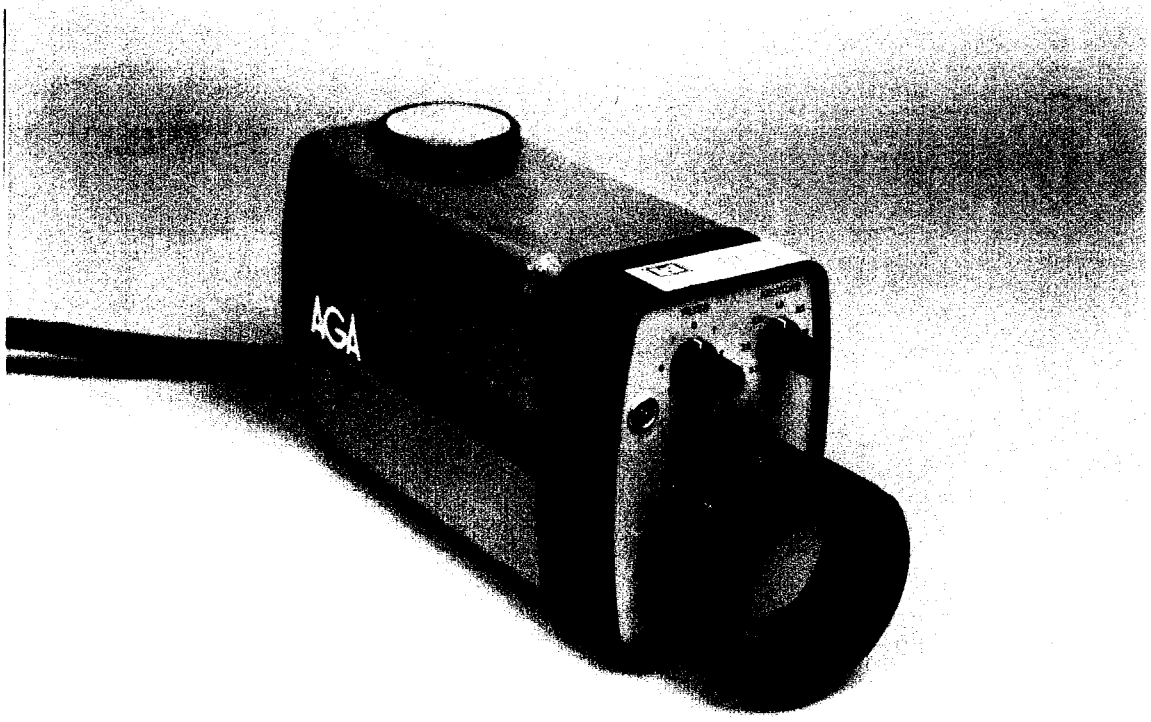


Figure 11. Agema 782 thermal scanner

Figure 12. Trimble 4000SST GPS receiver

Figure 13. Trimble Pathfinder GPS receiver

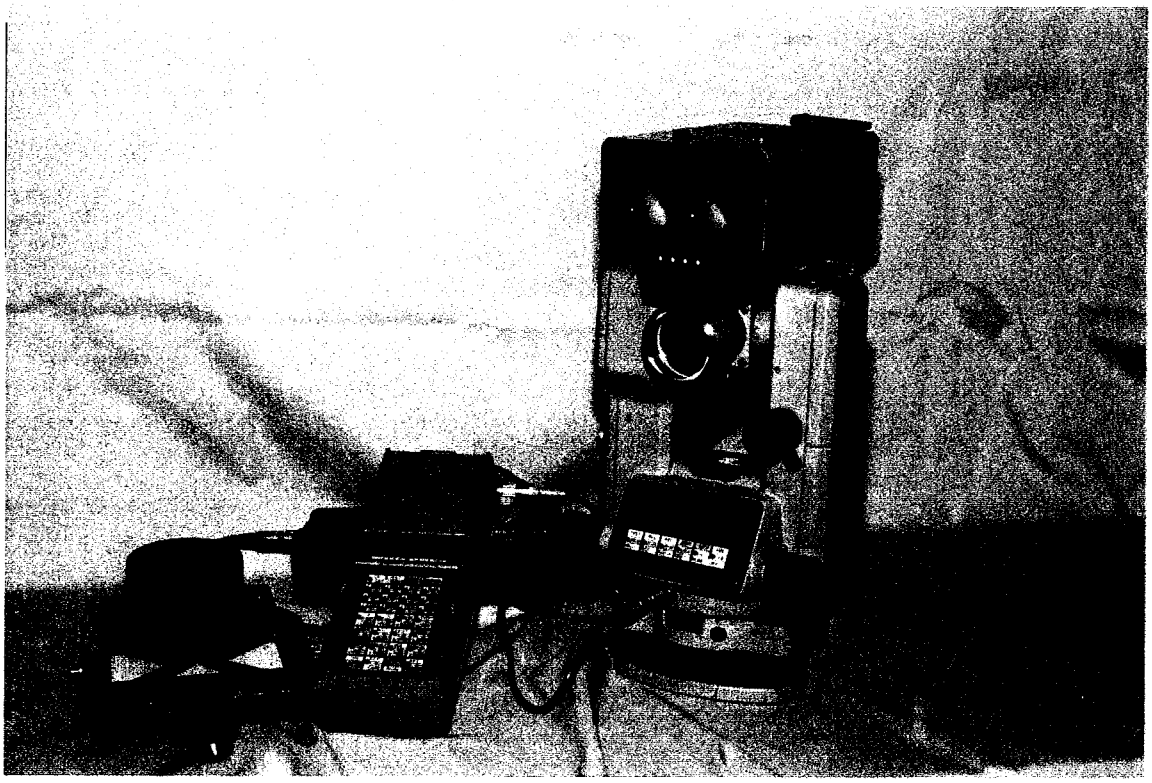


Figure 14. Wild T1000 theodolite and DI3000 range finder

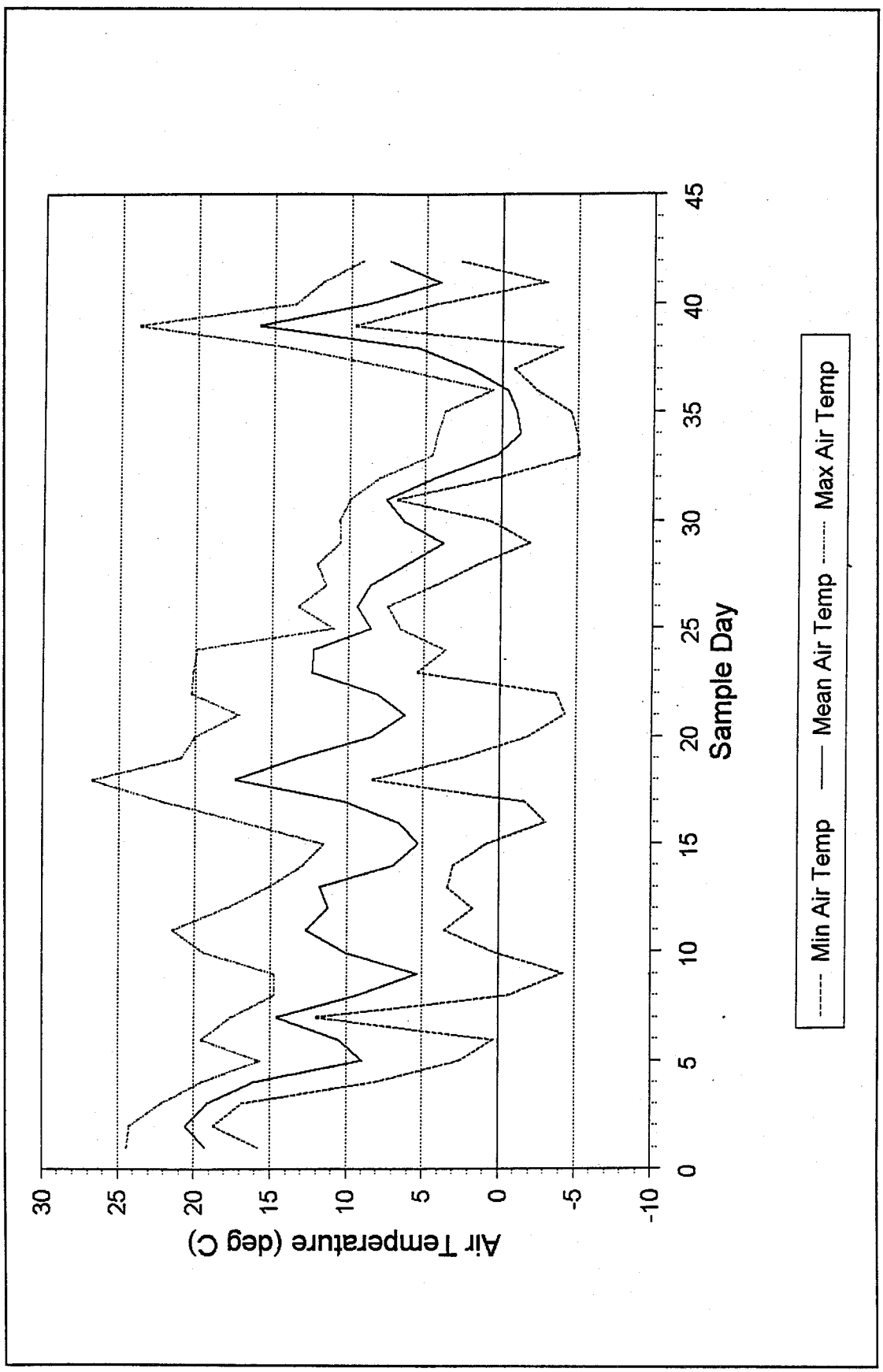


Figure 15. Daily minimum, maximum, and mean air temperature

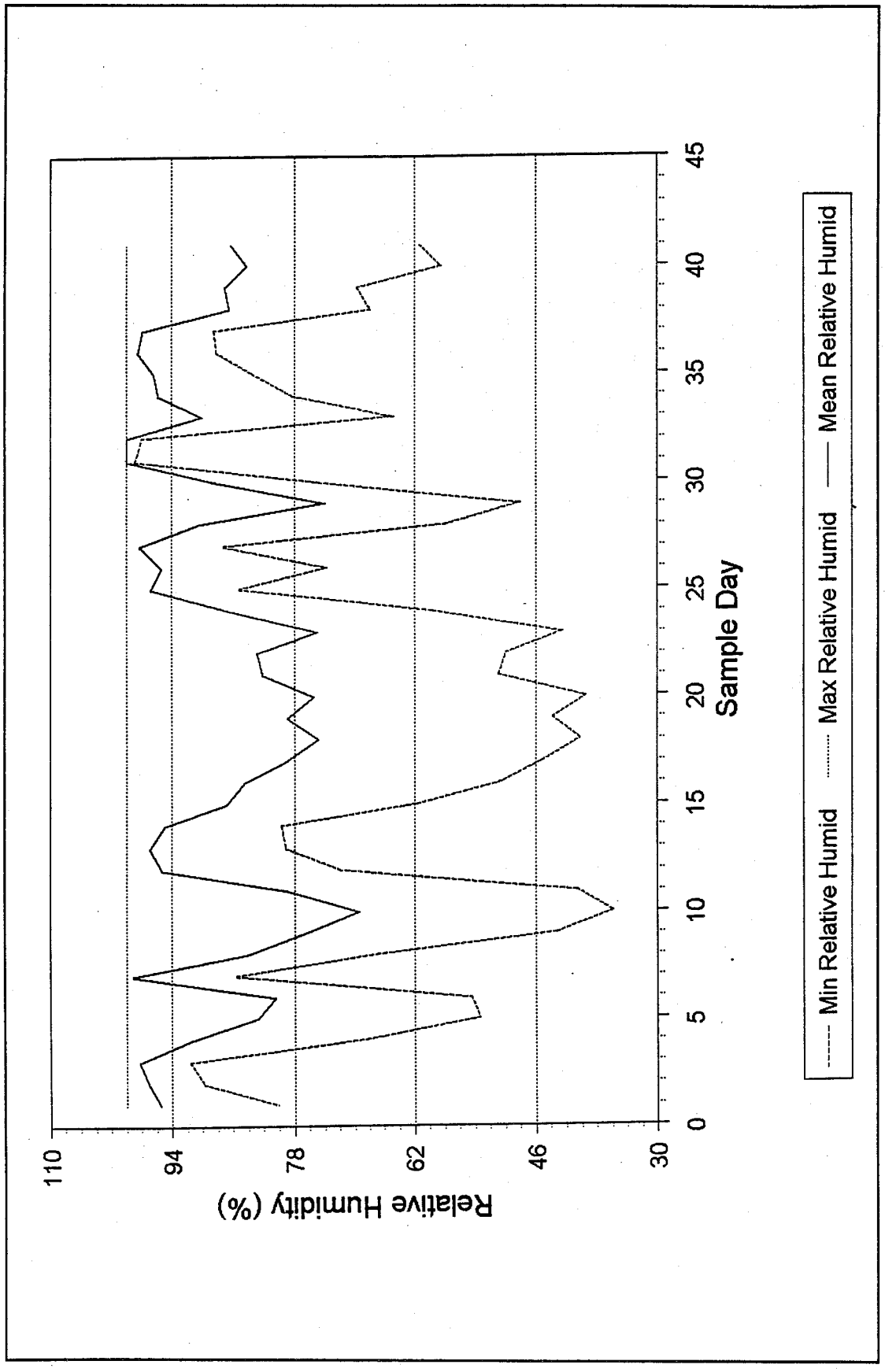


Figure 16. Daily minimum, maximum, and mean relative humidity

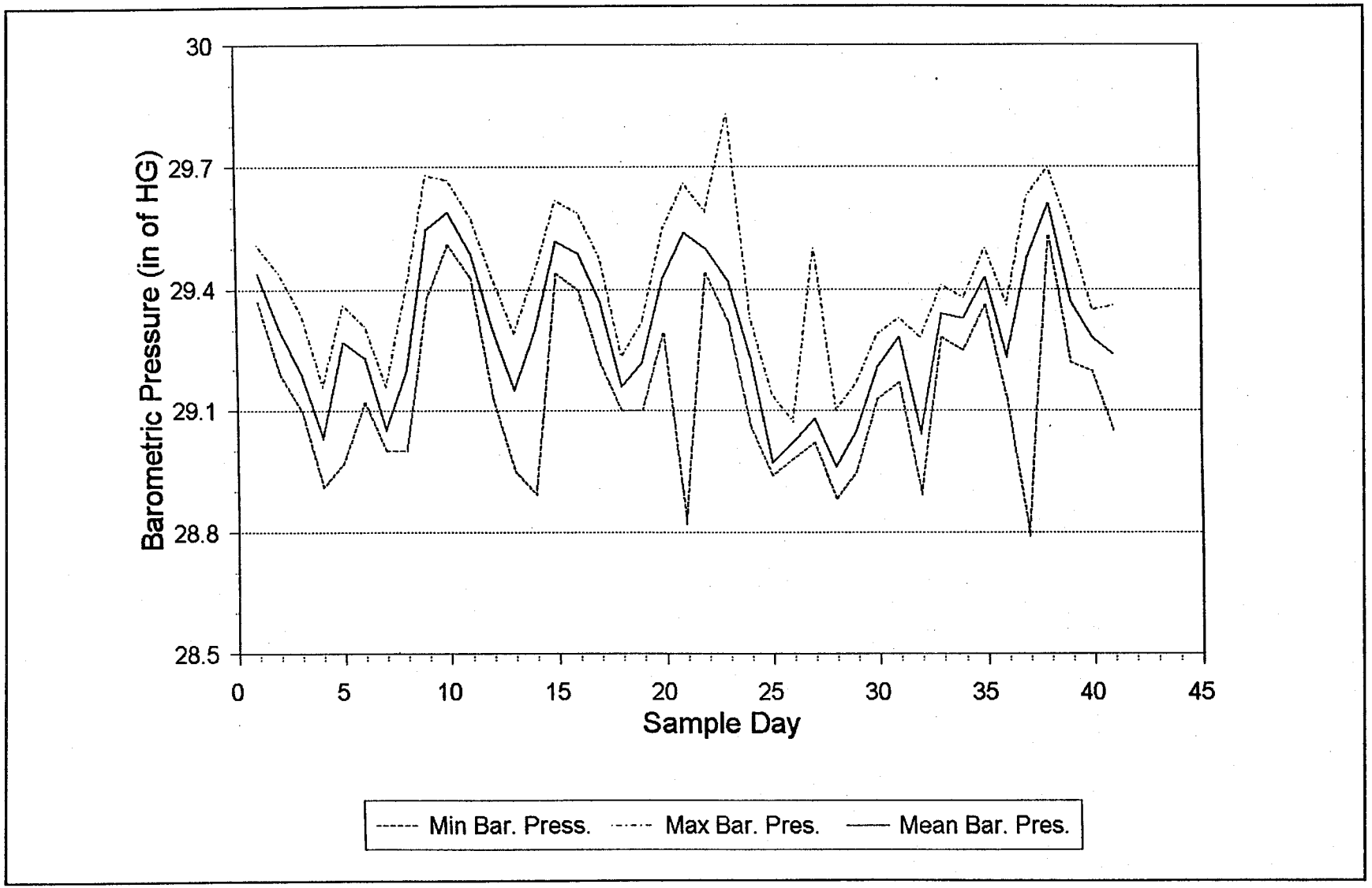


Figure 17. Daily minimum, maximum, and mean barometric pressure

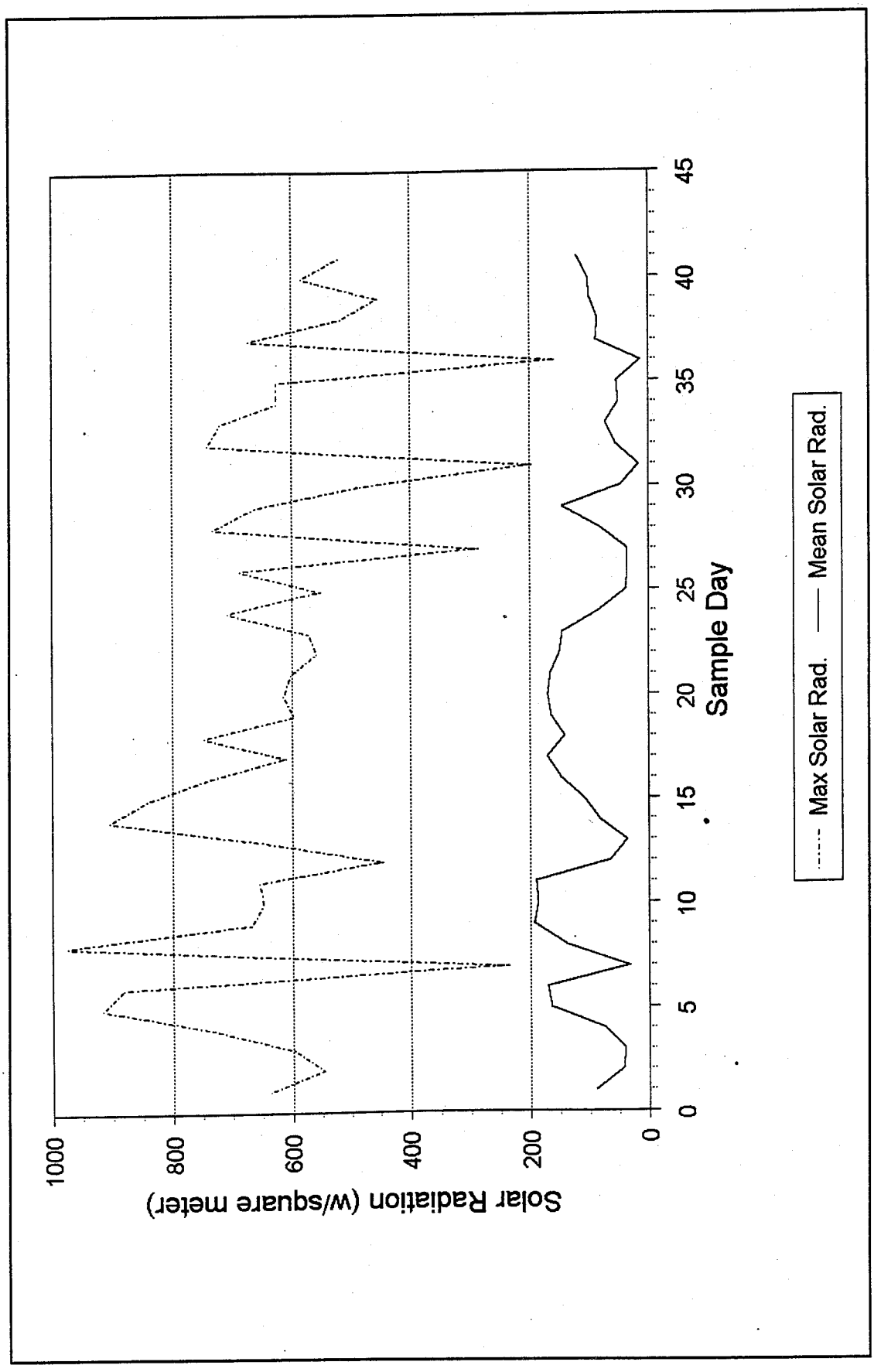


Figure 18. Daily maximum and mean solar radiation

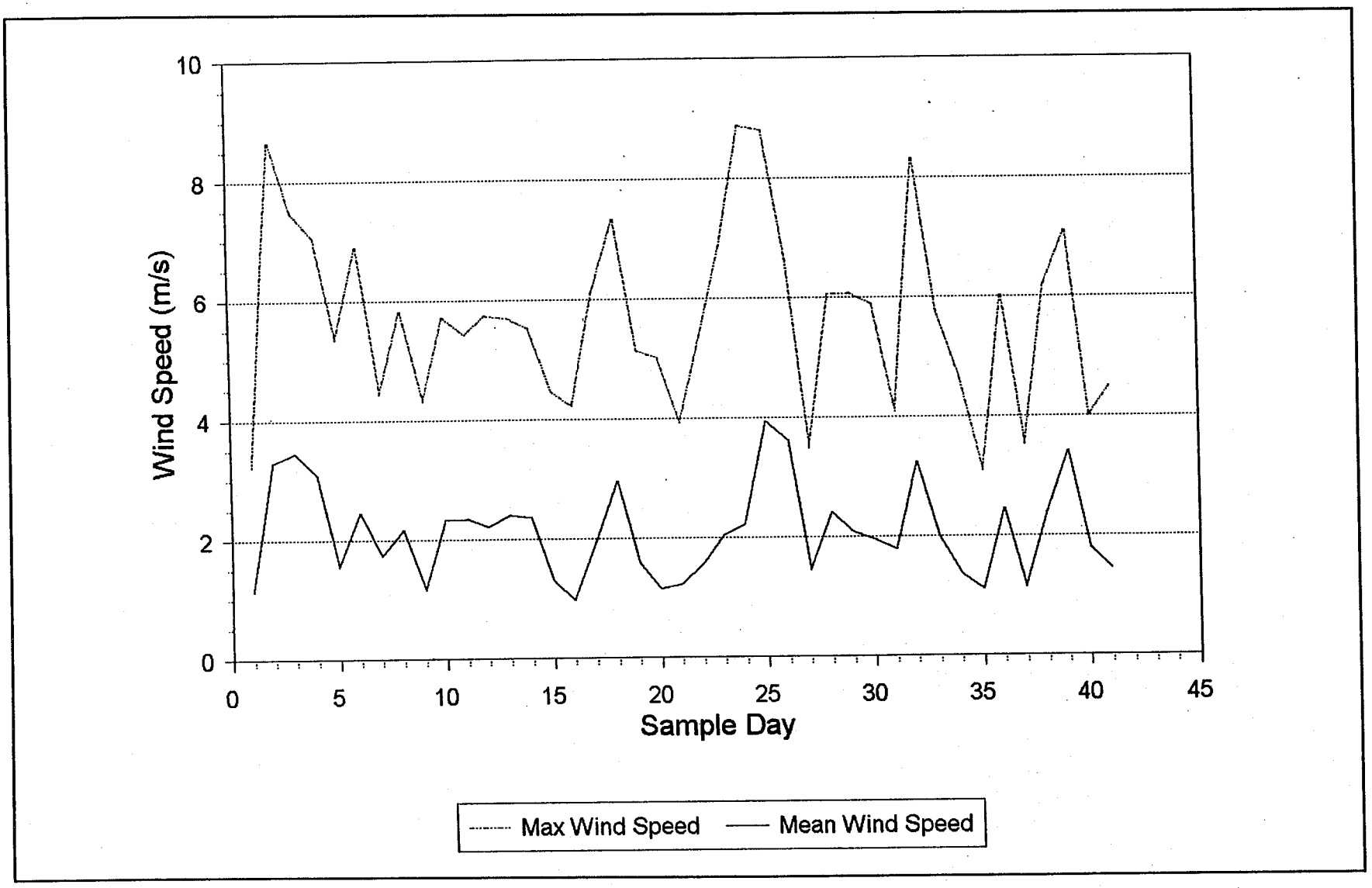


Figure 19. Daily maximum and mean wind speed

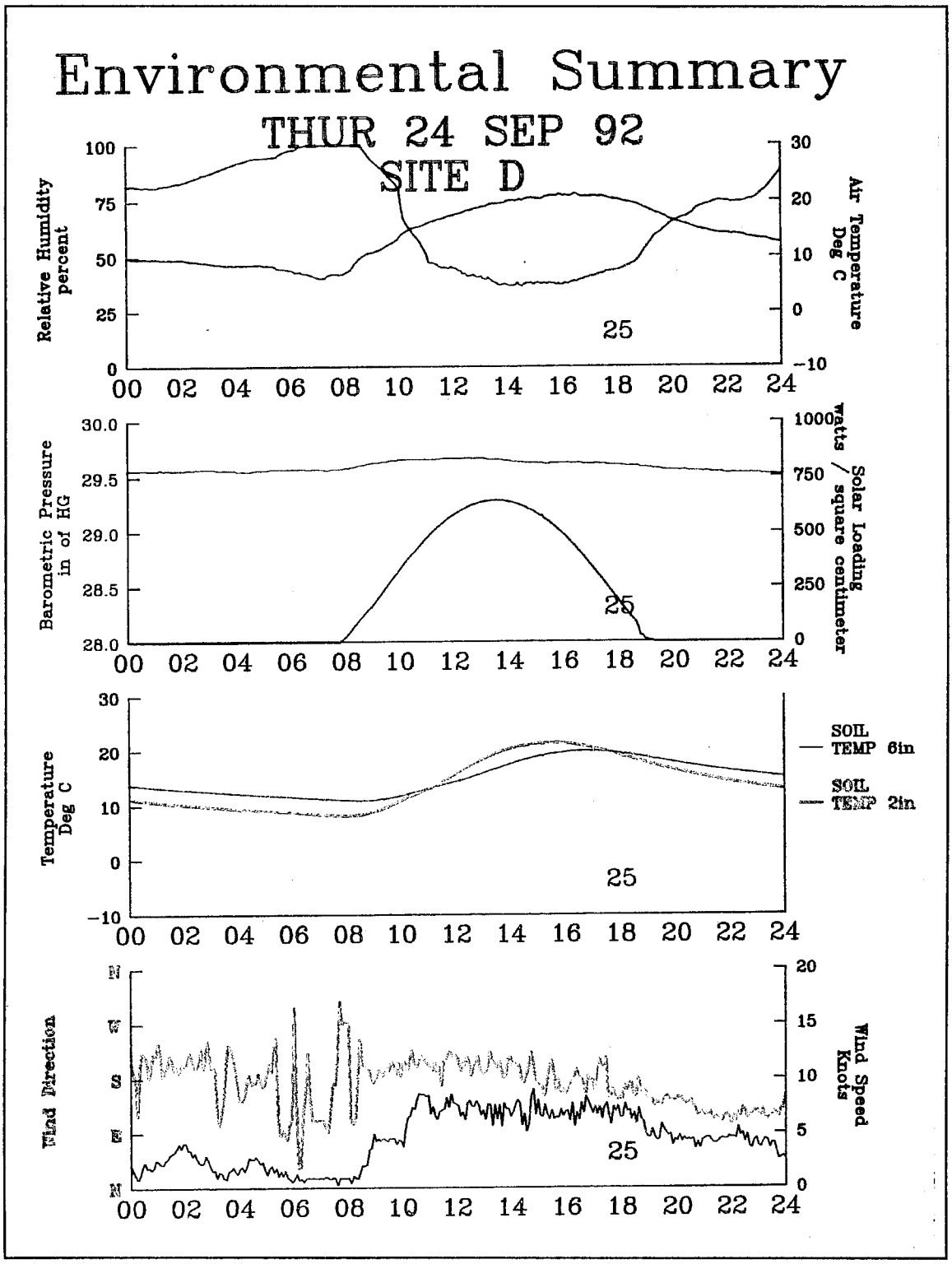


Figure 20. Sample meteorological data plot, Site D

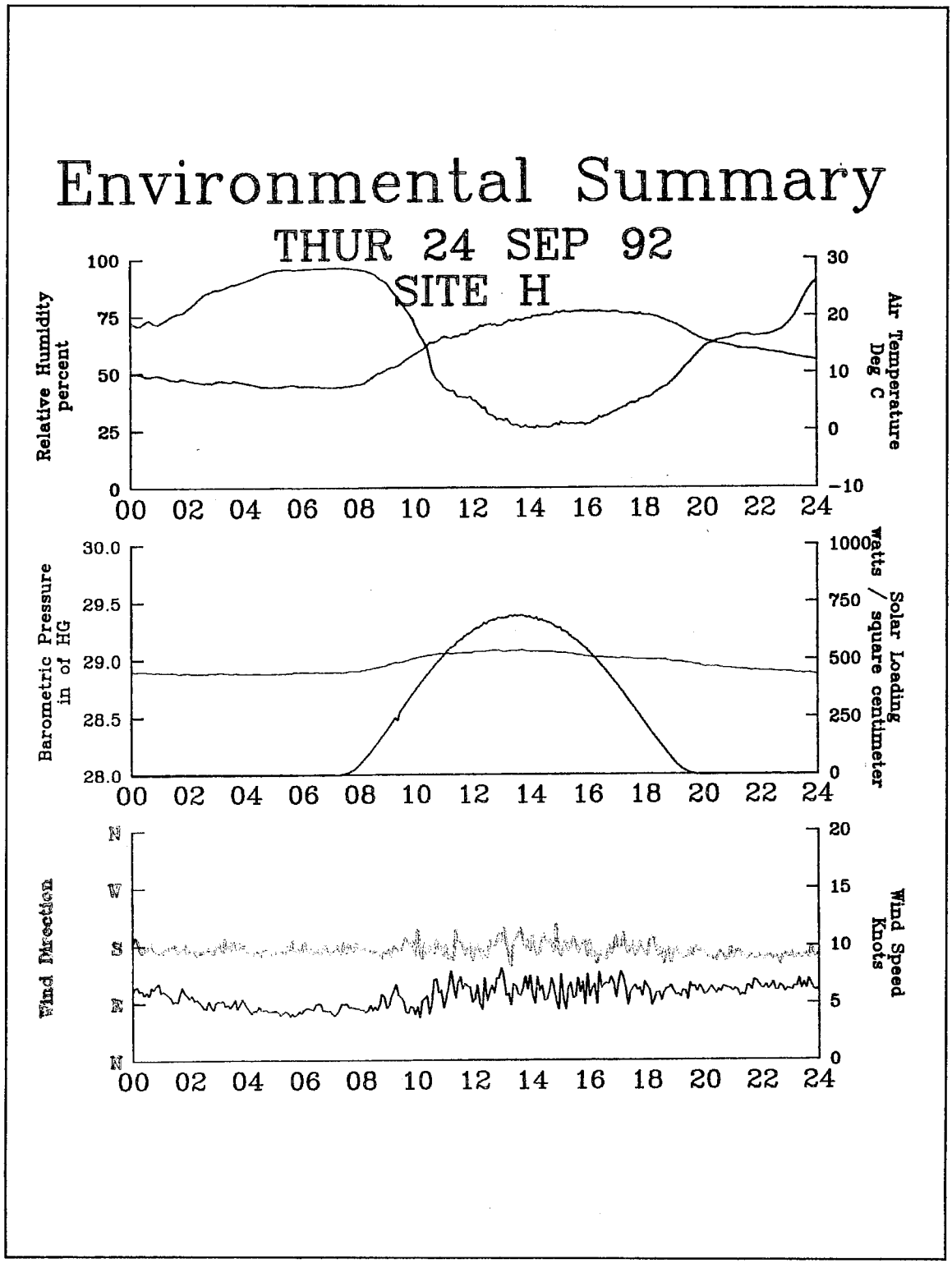


Figure 21. Sample meteorological data plot, Site H

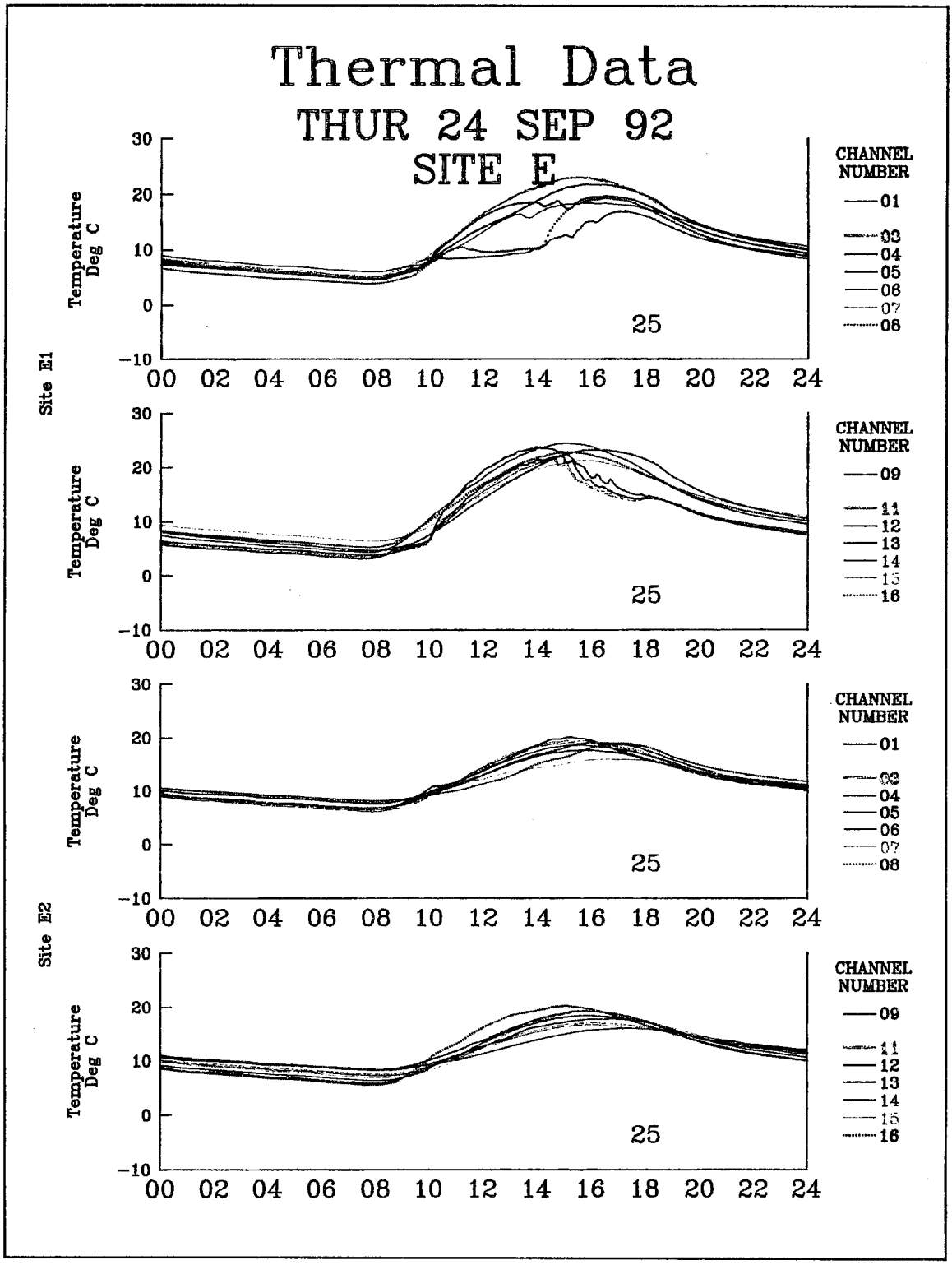


Figure 22. Sample thermistor data plot, Site E

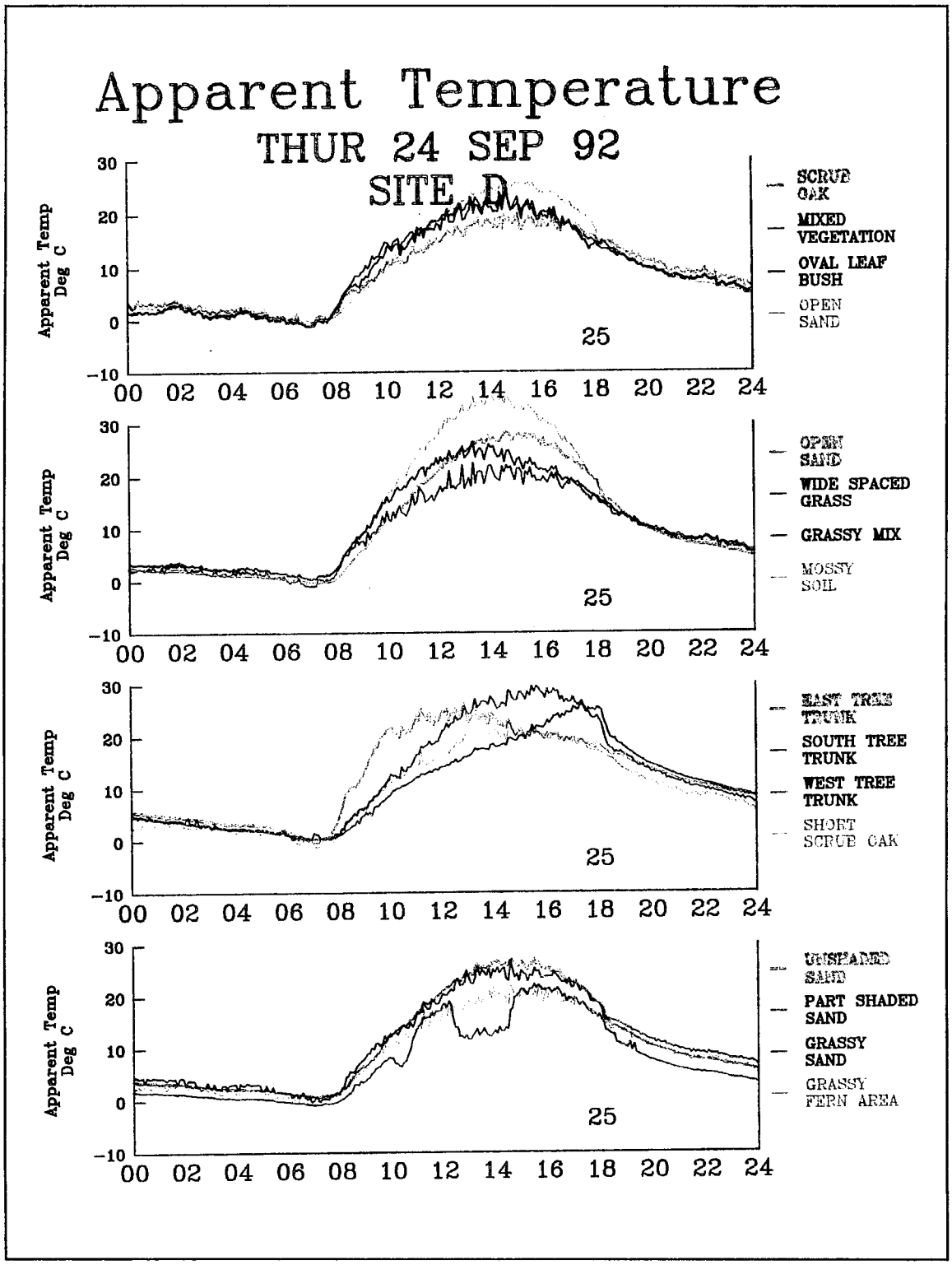


Figure 23. Sample staring radiometer data plot, Site D

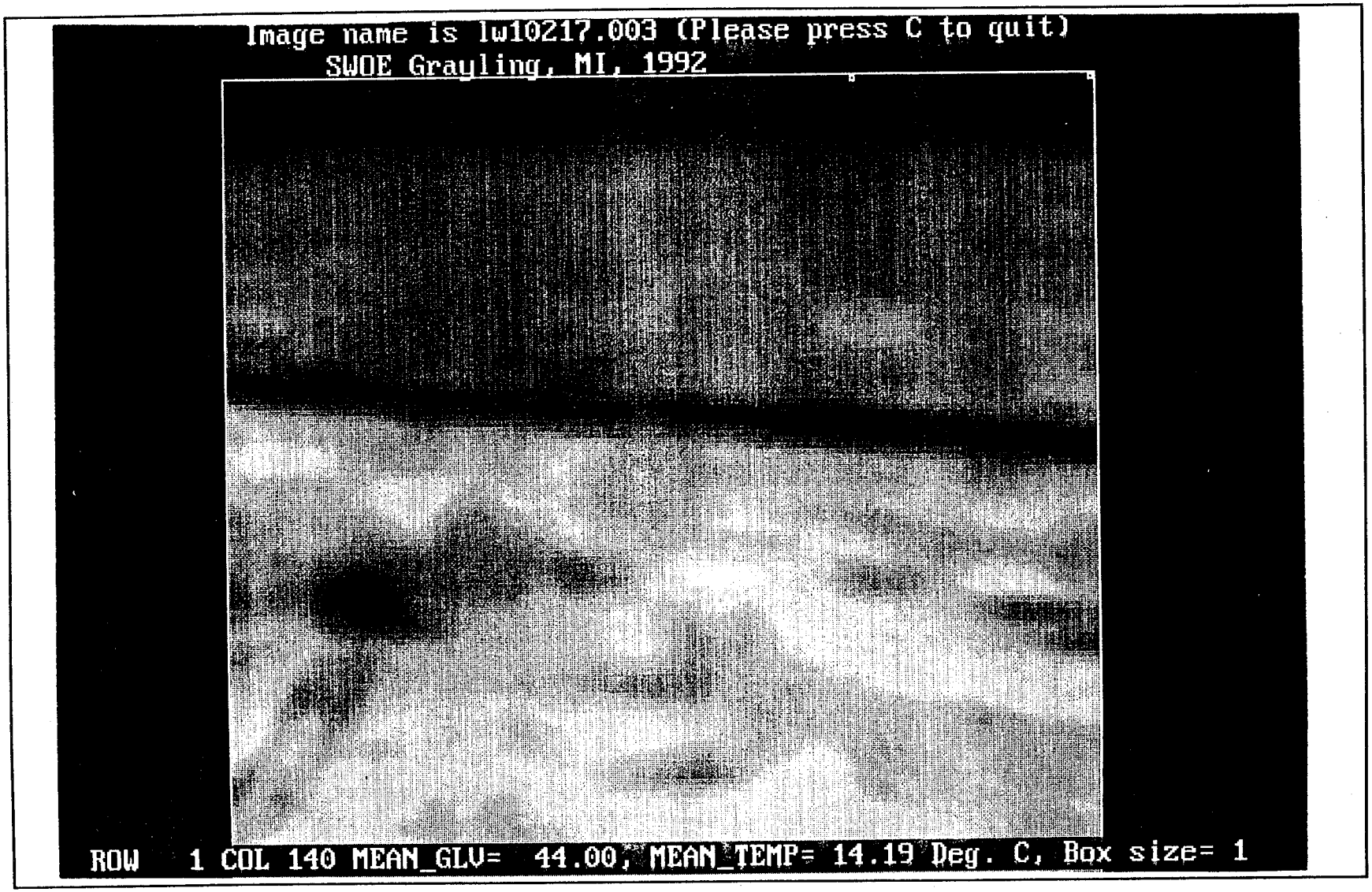


Figure 24. Sample LWB image

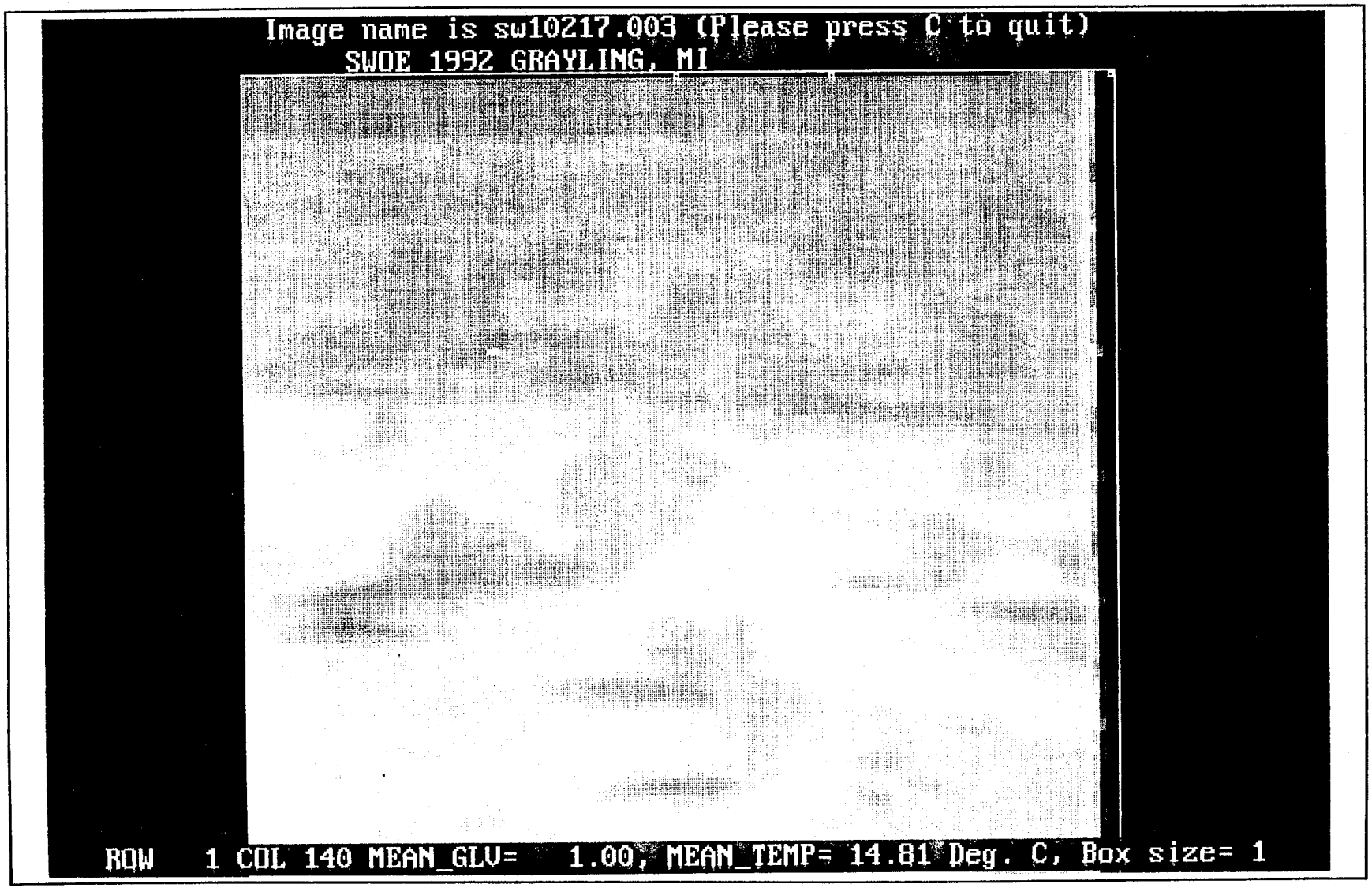


Figure 25. Sample SWB image

Month	SEP																	OCT																					Month
Time	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Time
0				011														040				052								076		080					093		101		106	0
1		004	008	011	014																050	052	056				067			076		080					093	098	101			1
2		004	008		014										033						050		056				067	069									094	098				2
3															033					047				060				069	073						088		094			103		3
4																				047		053		060					073		078				088					103		4
5																		041				053	057								078						095					5
6	001	005																041					057														095					6
7	001	005						021											044	048													083								7
8	002	006						021	023								037	042	044	048			058		063								083	086	089					104		8
9	002	006	009	012		017			023								037	042					058		063	065			074					086	089					104		9
10			009	012		017	019															054				065		070	074		079						096					10
11				013			019						030				038					054		061				070			079					092	096		102			11
12				013			020						030				038							061												092	097		102			12
13					015	018	020																									081					097					13
14					015	018			024						034													071				081										14
15			010						024			028			034				045		051						068	071										099				15
16	003		010		016			022				028							045		051	055					068			077		082						099			107	16
17	003				016			022		025	026			032		036						055								077		082	084		090					105	107	17
18										025	026	029	031	032		036				049													084		090			100		105		18
19												029	031		035				046	049			059															100				19
20		007													035		039		046				059	062										087								20
21		007															039	043						062				072					085	087	091							21
22											027							043							064	066		072	075				085		091							22
23											027						040								064	066			075											106		23

Figure 26. Imaging schedule for Grayling 1

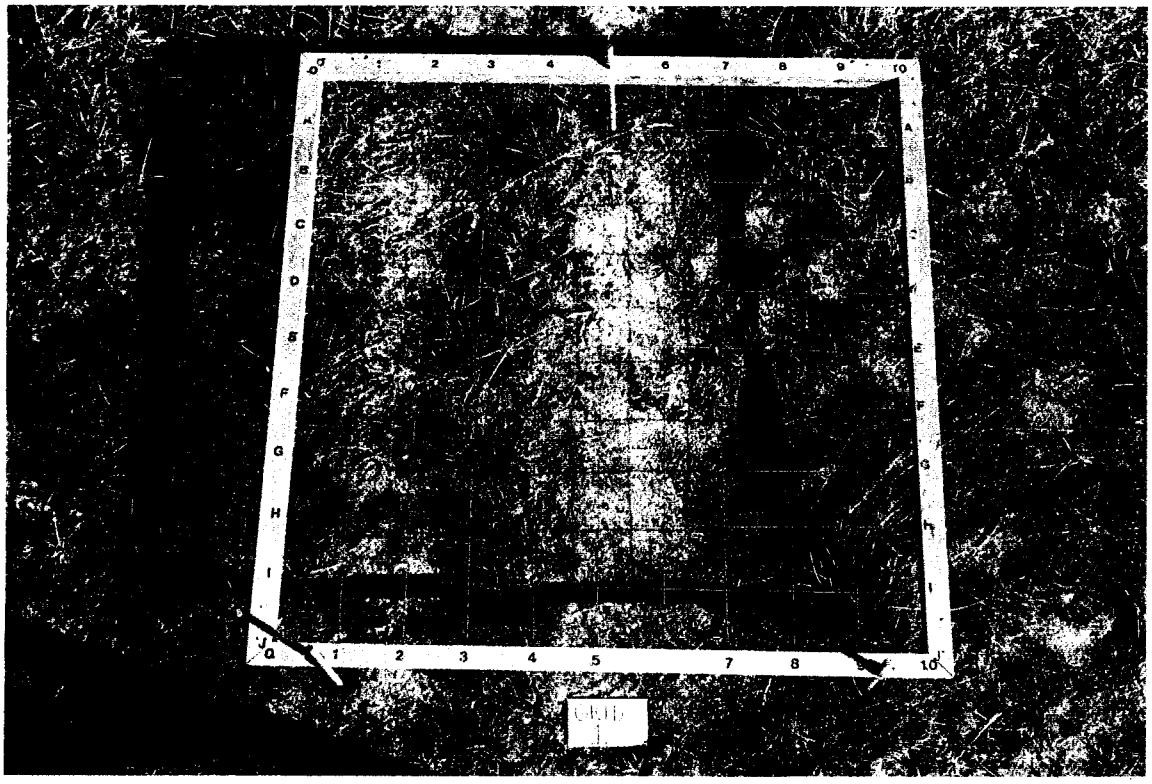


Figure 27. Surface roughness Grid 1, Site E1

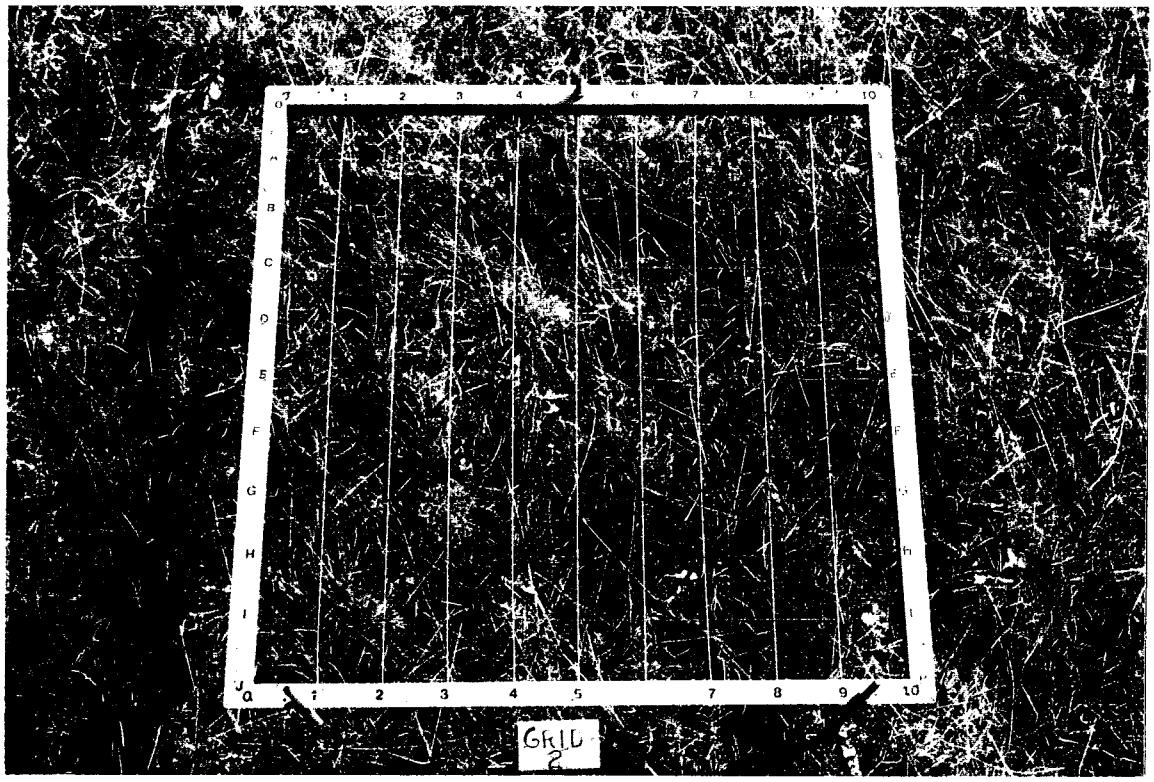


Figure 28. Surface roughness Grid 2, Site E1

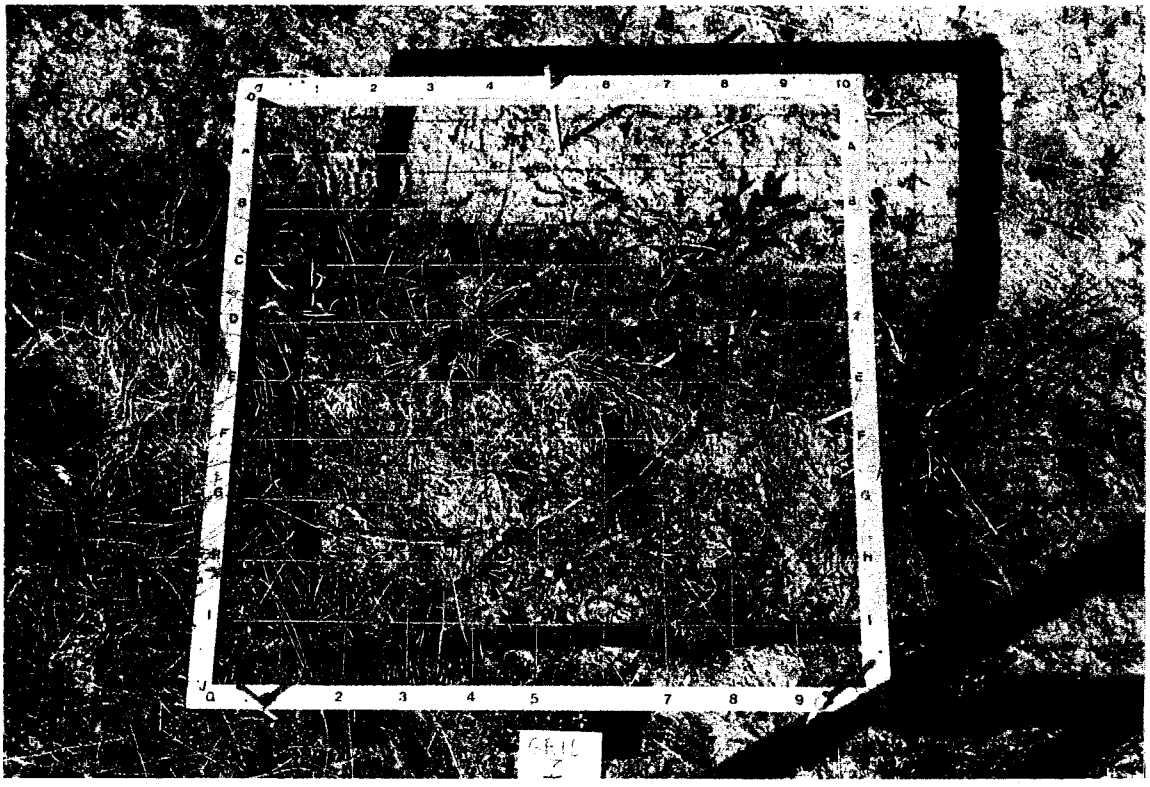


Figure 29. Surface roughness Grid 3, Site E2

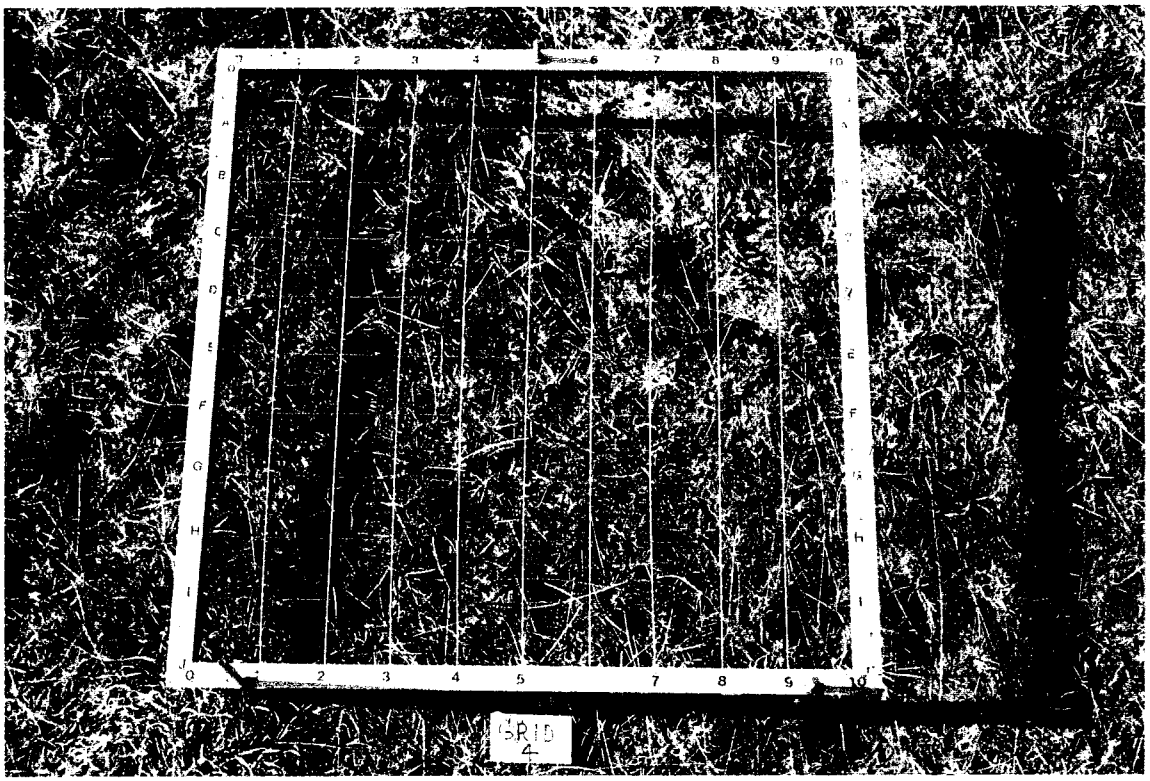
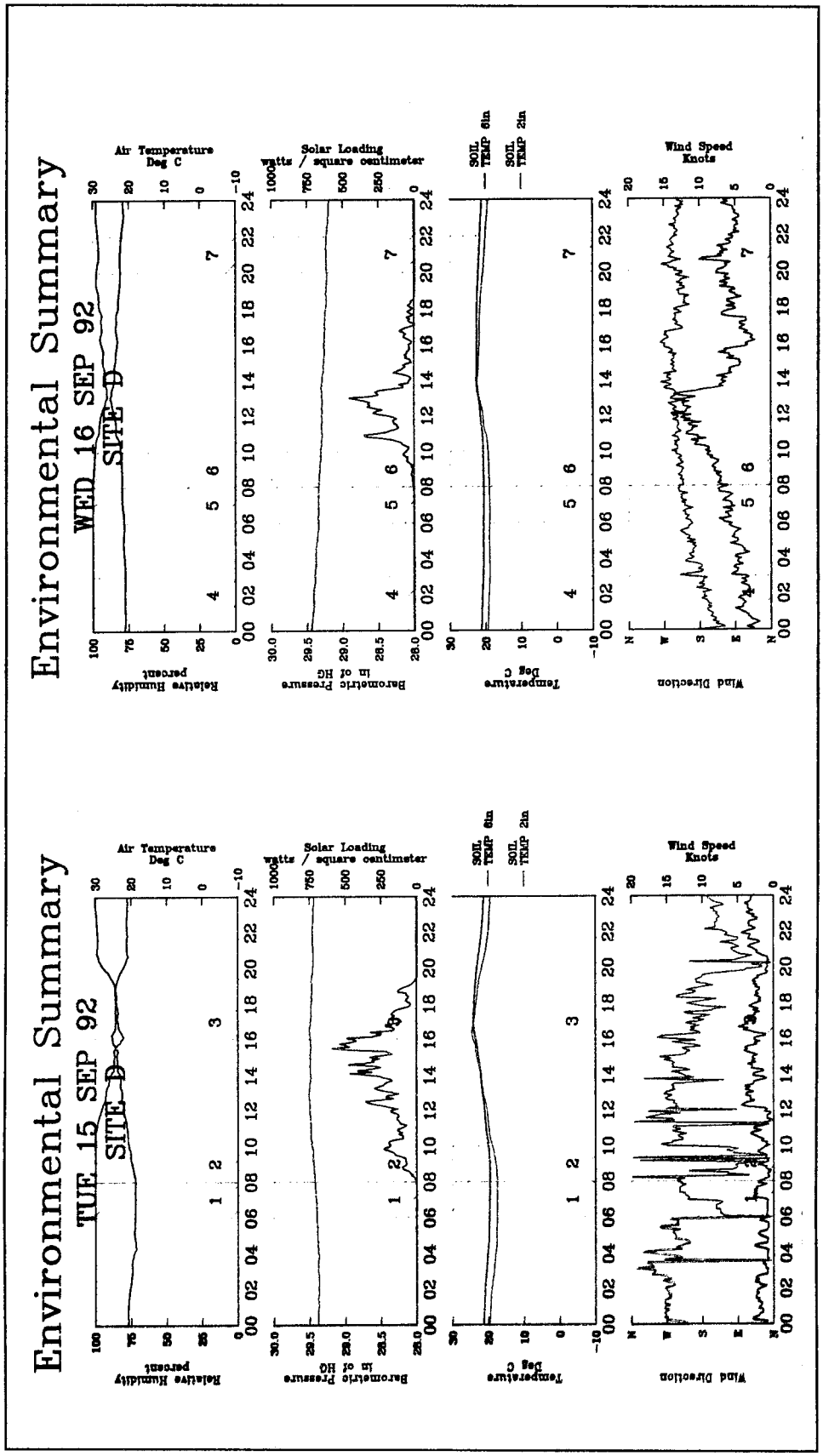


Figure 30. Surface roughness Grid 4, Site E2

Appendix A
Meteorological and Environmental Data Summaries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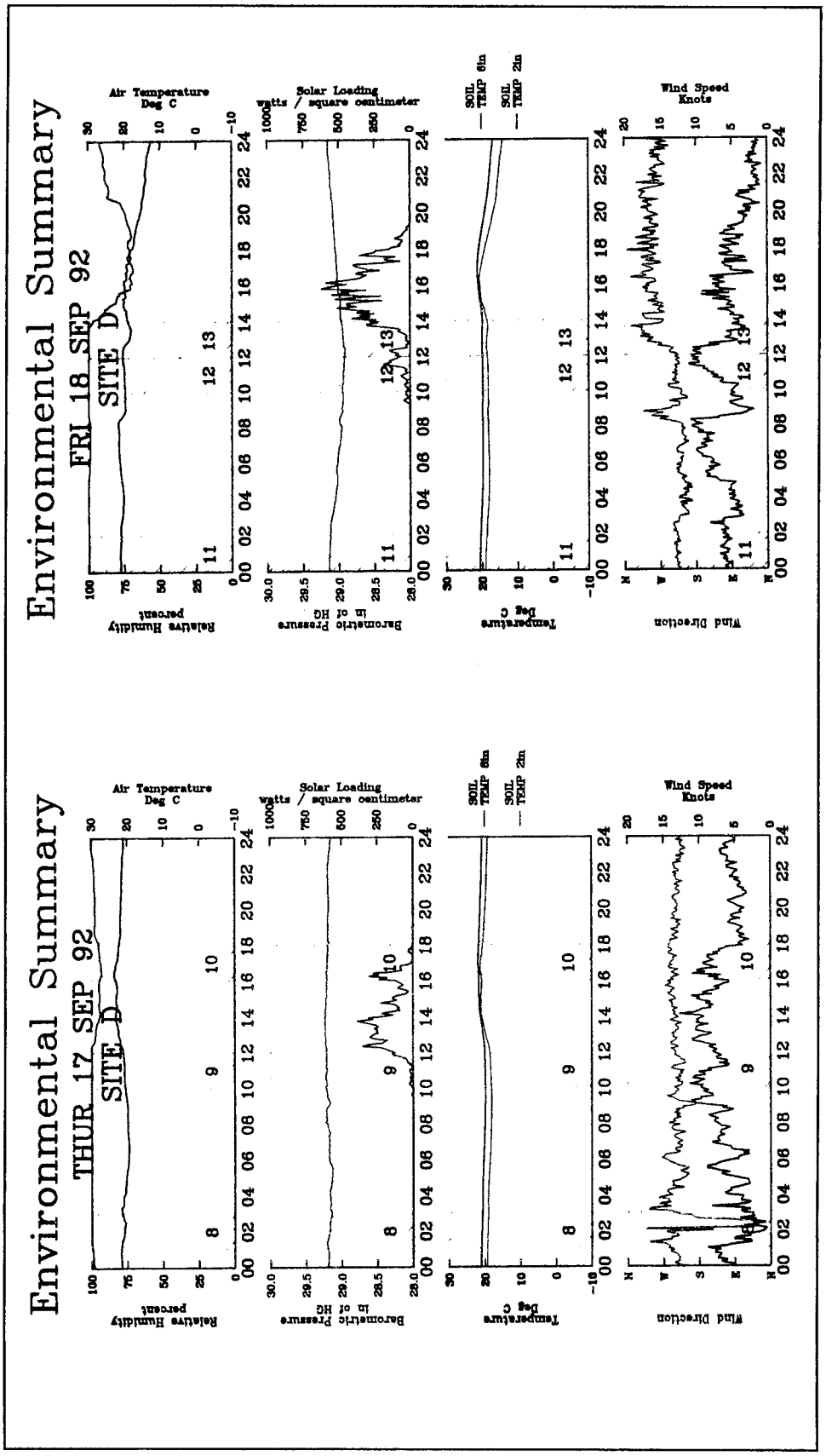
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
TUE 15 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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Deg C
Solar Loading
watts / square centimeter
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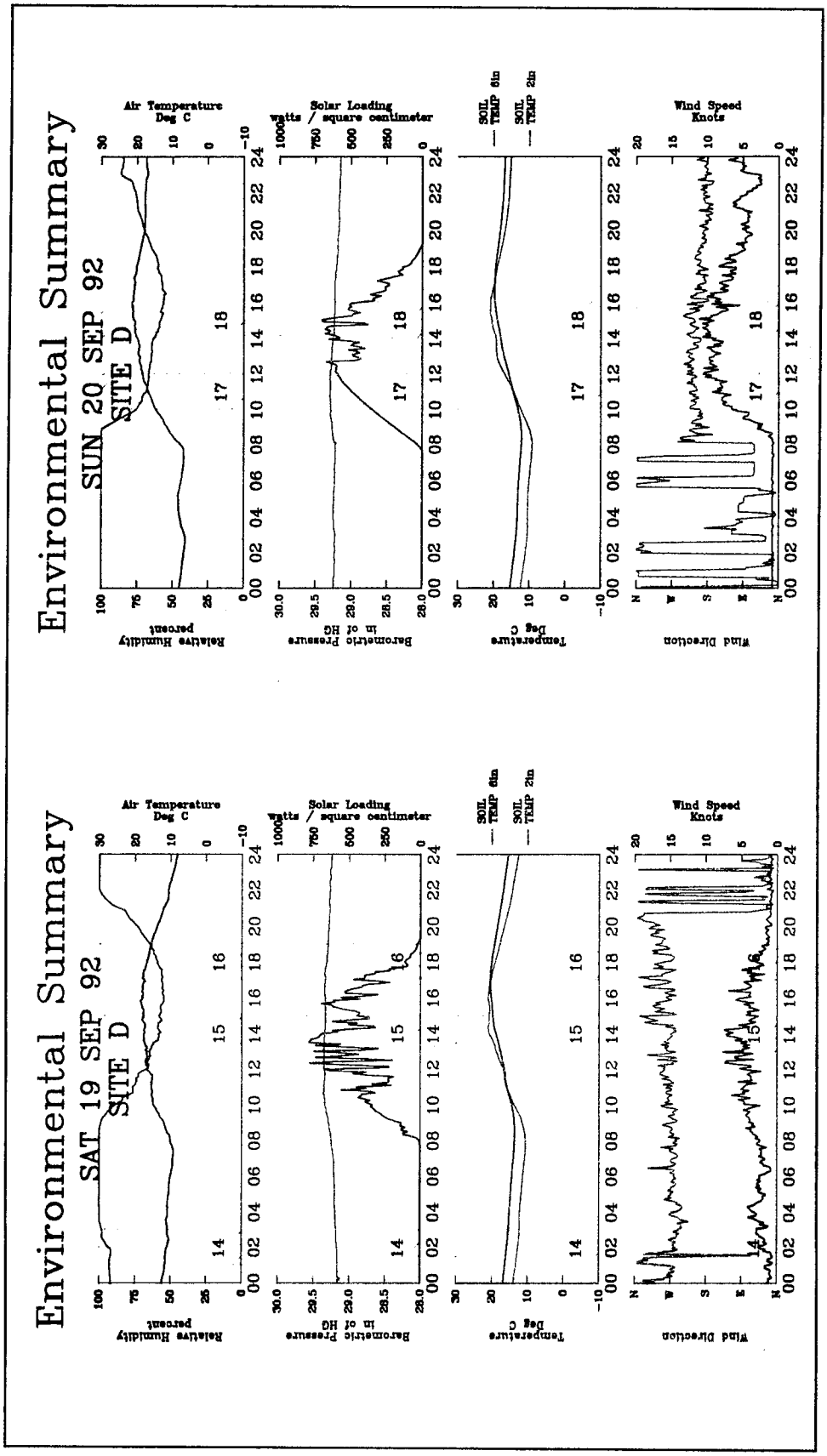
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
THUR 17 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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watts / square centimeter
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SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
SAT 19 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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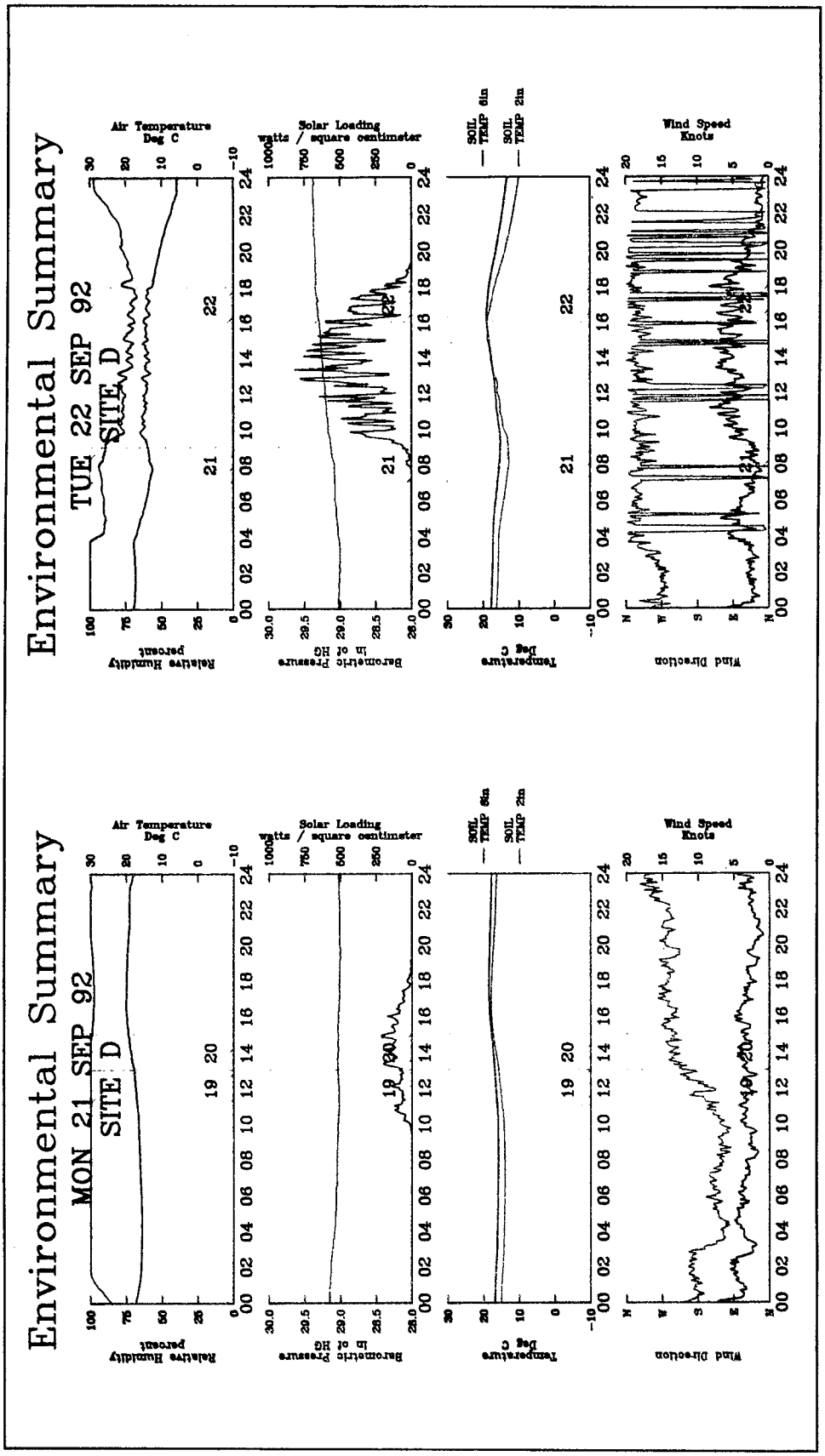
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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Solar Loading
watts / square centimeter
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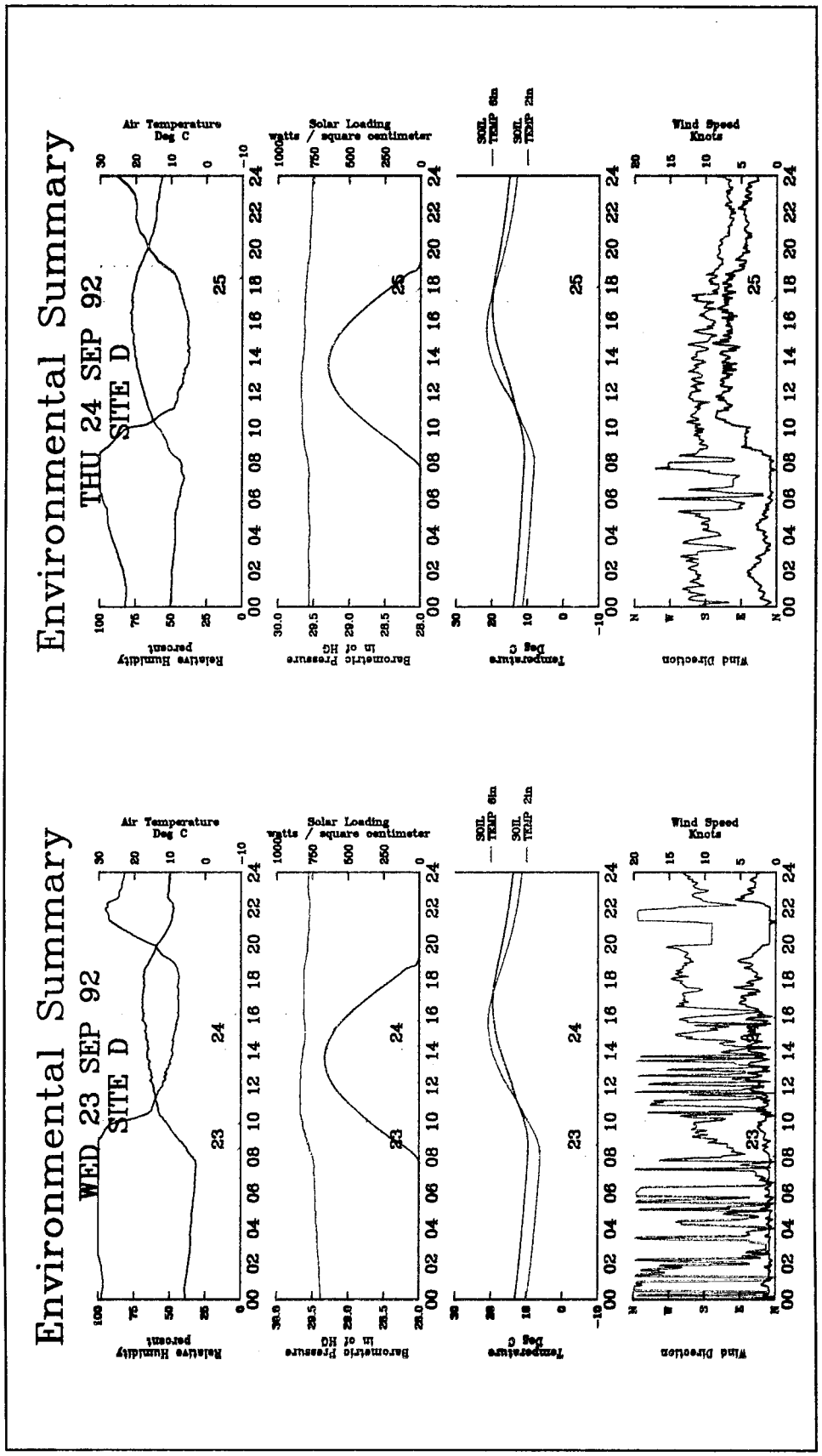
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
MON 21 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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watts / square centimeter
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Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction
25
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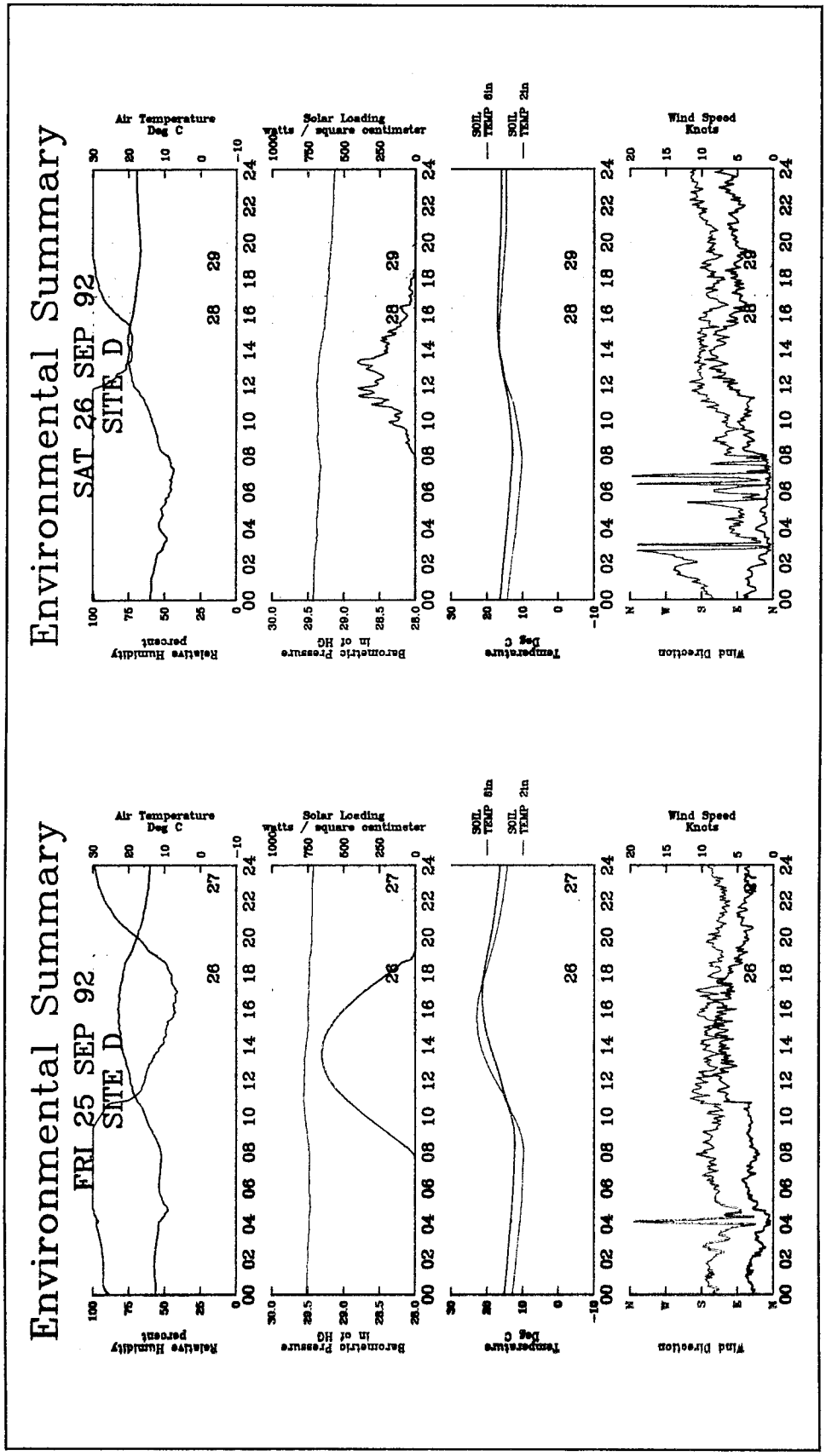
WED 23 SEP 92
SITE D
23
24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watts / square centimeter
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SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
FRI 25 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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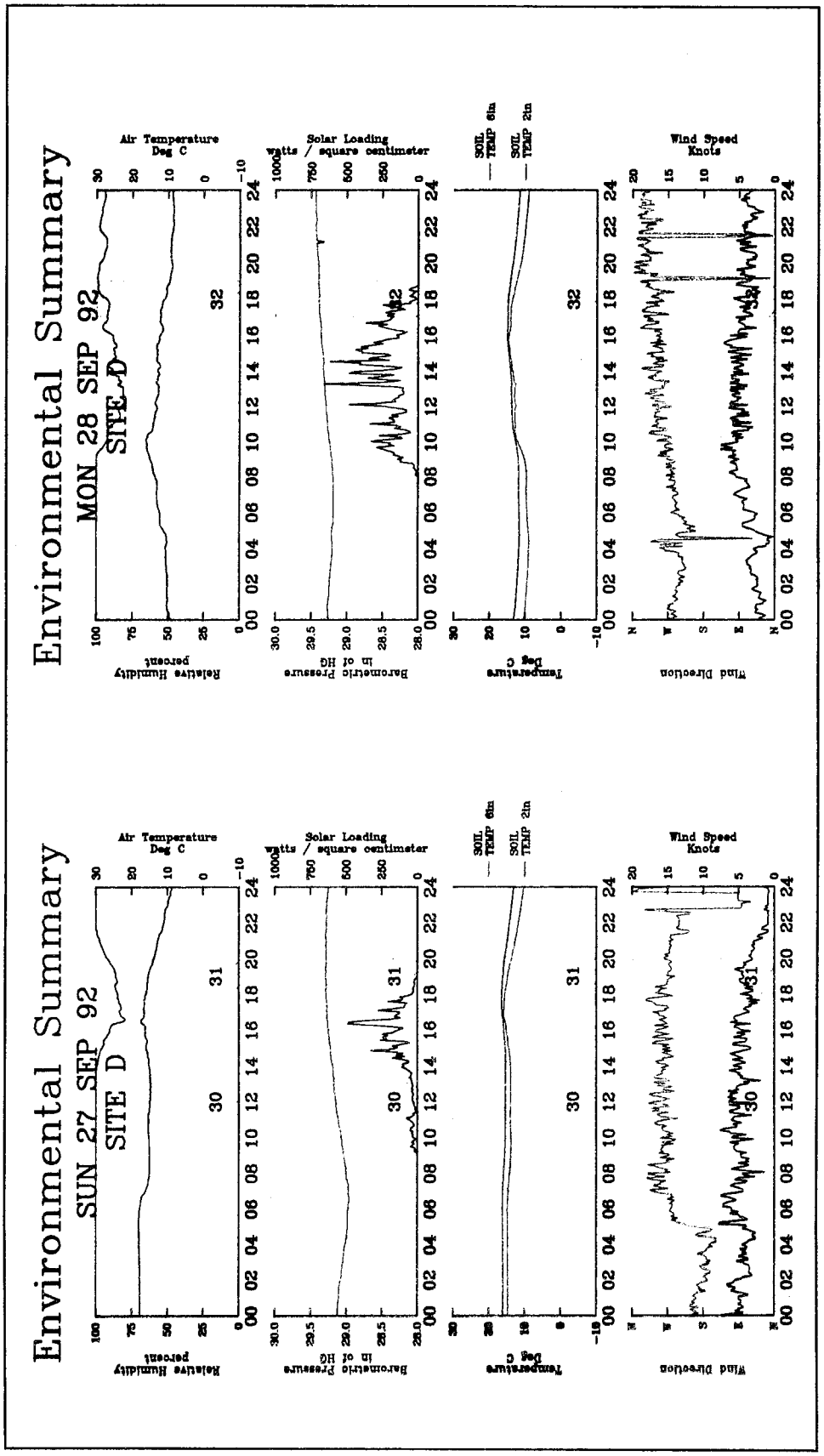
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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Air Temperature
Deg C
Solar Loading
watts / square centimeter
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SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
SUN 27 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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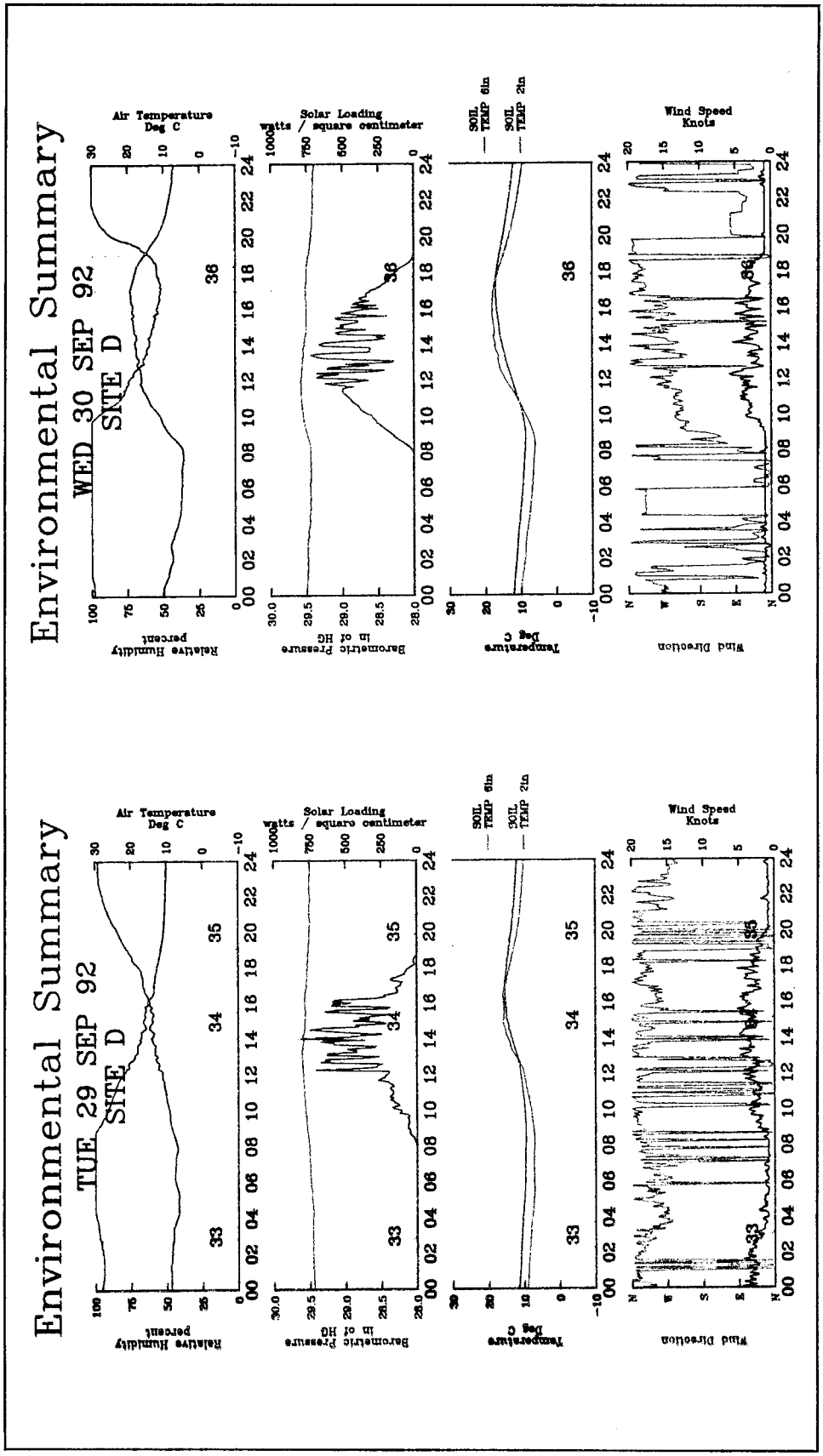
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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watts / square centimeter
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Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction
Environmental Summary
TUE 29 SEP 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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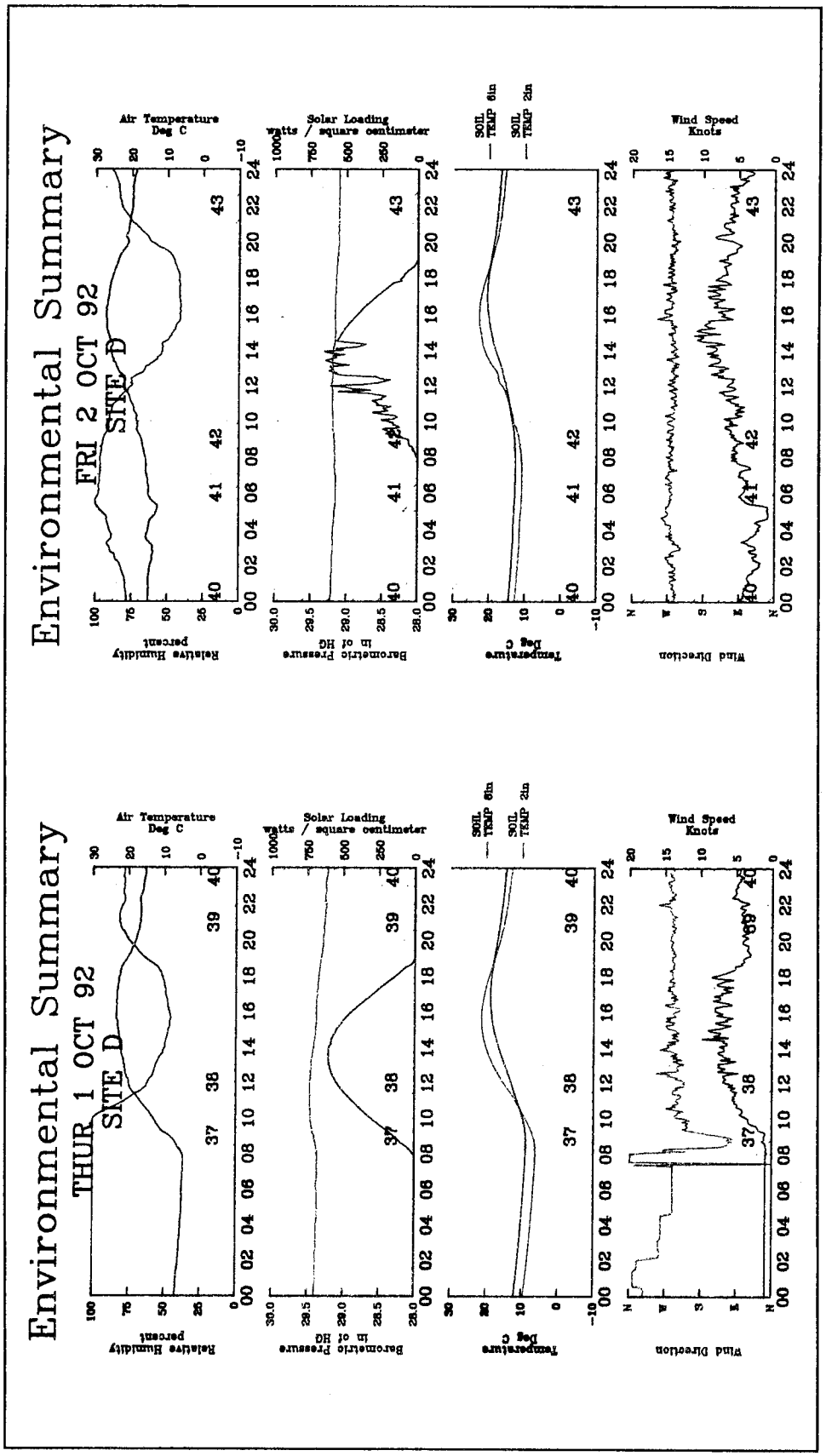
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction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watts / square centimeter
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Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
THUR 1 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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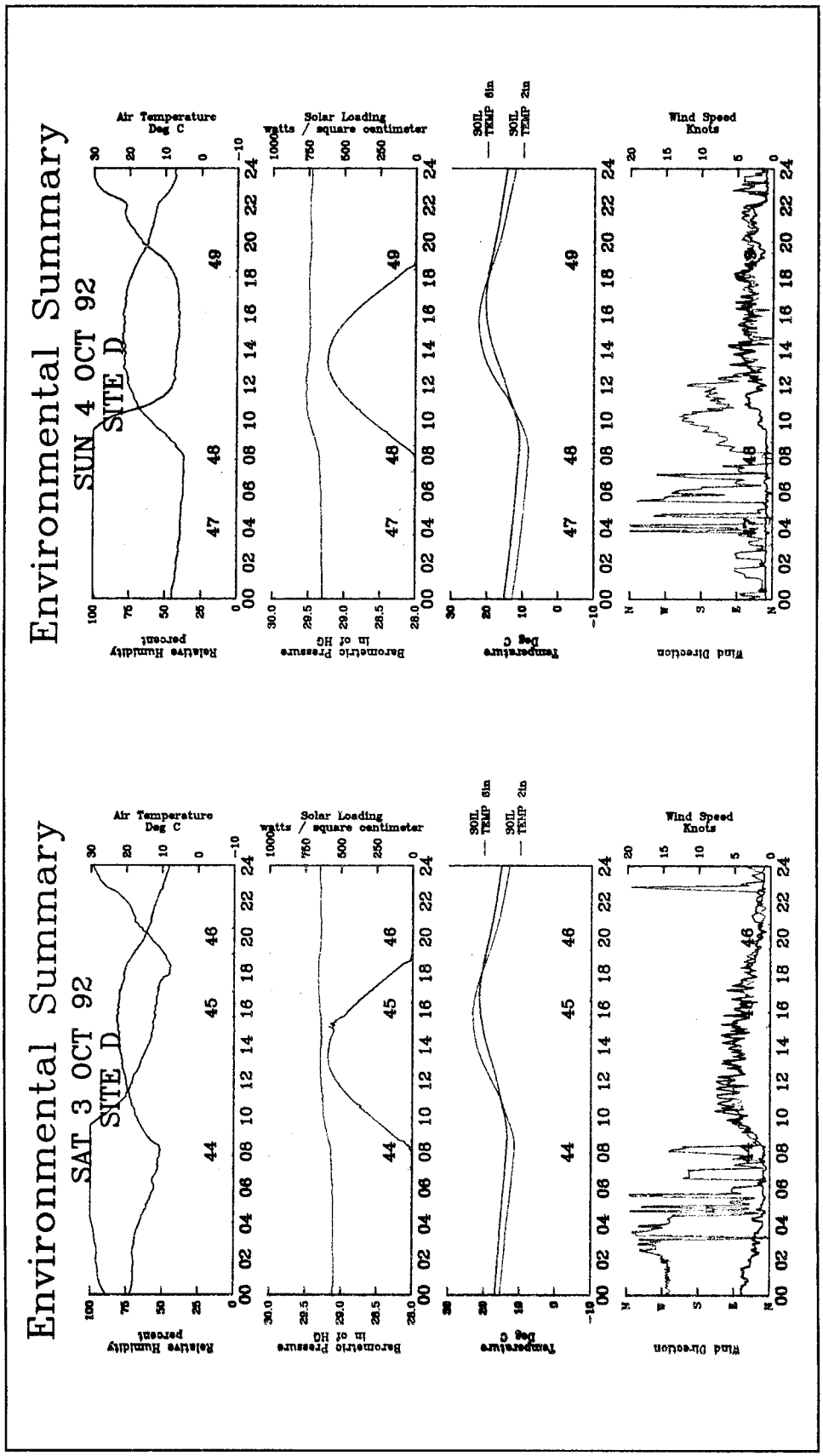
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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watts / square centimeter
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Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
SAT 3 OCT 92
SITE D
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Deg C
Solar Loading
watts / square centimeter
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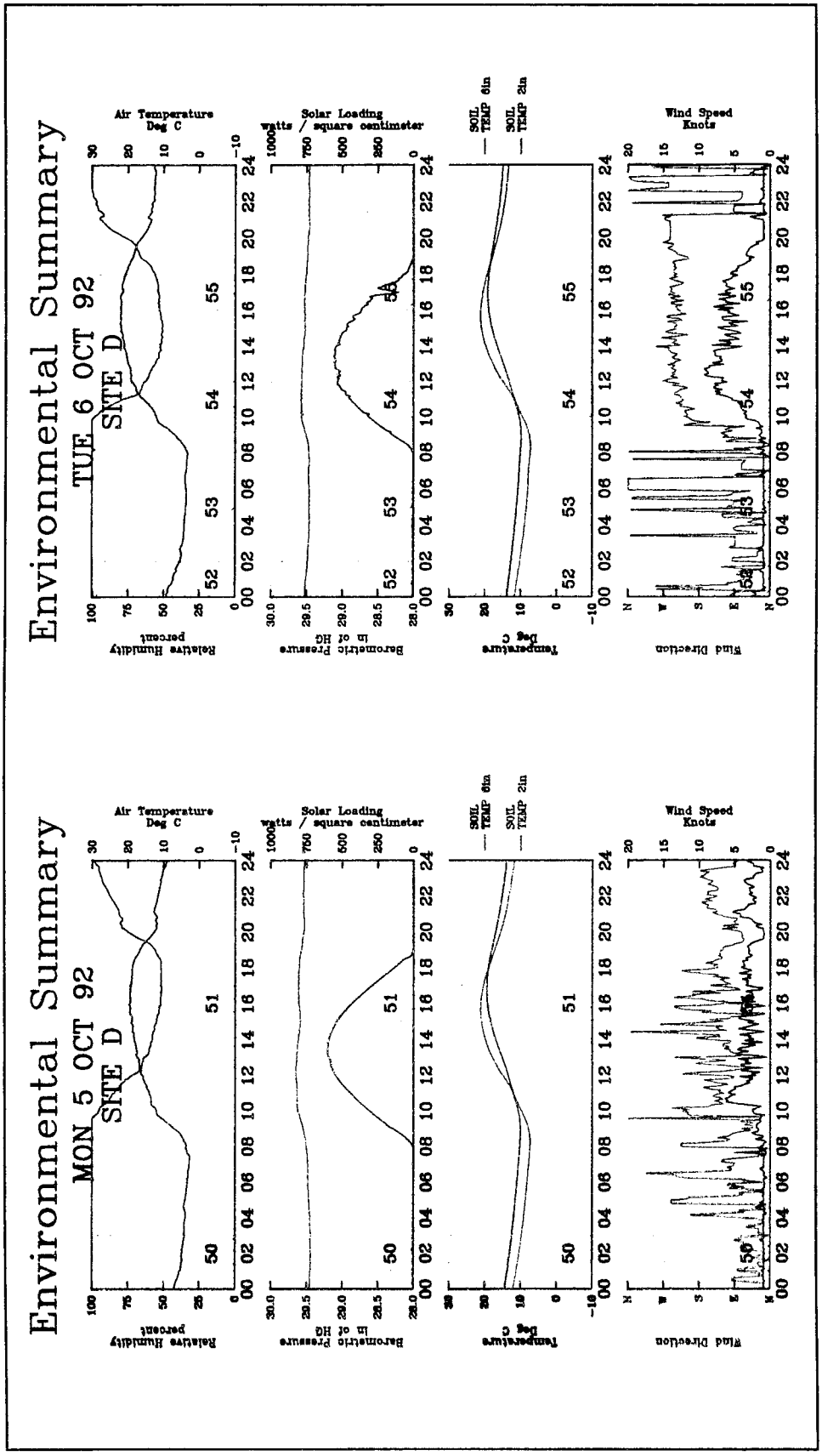
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction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Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
SOIL TEMP 6in
SOIL TEMP 2in
Temperature
Deg C
Wind Speed
Knots
Wind Direction
Environmental Summary
MON 5 OCT 92
SITE D
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
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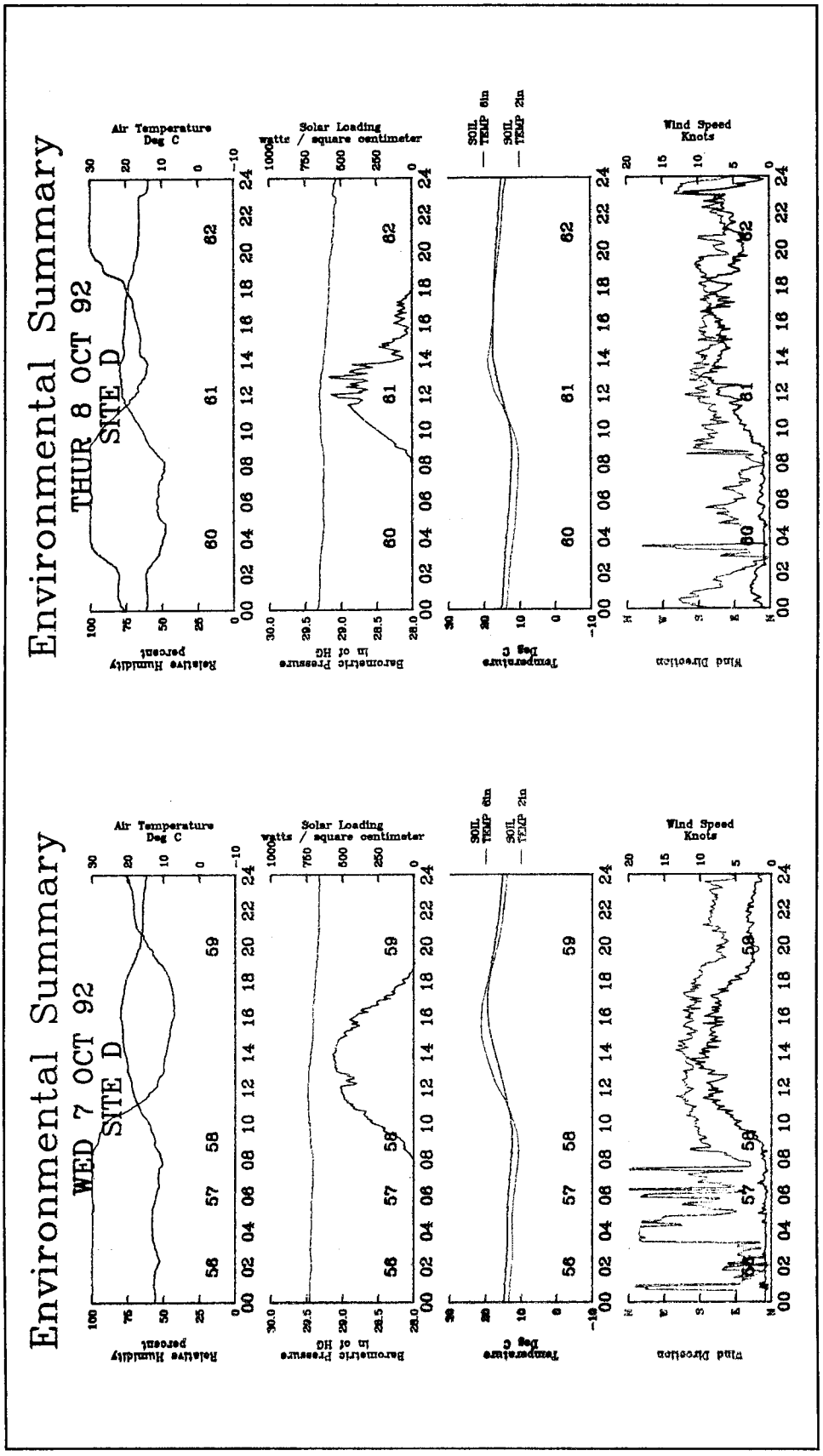
Temperature
Deg C
Wind Speed
Knots
Wind Direction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Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
WED 7 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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Wind Speed
Knots
Relative Humidity
percent
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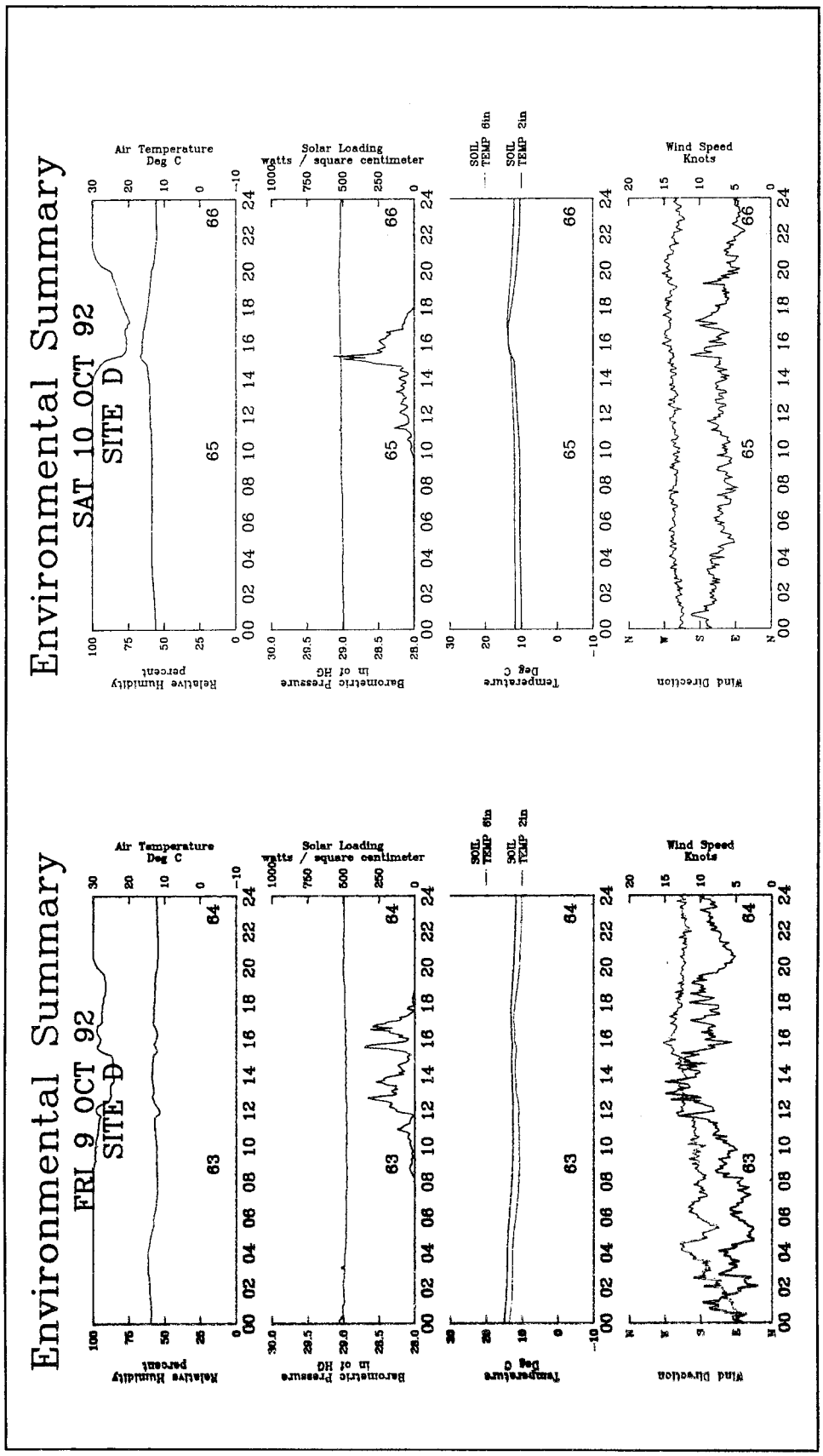
Temperature
Deg C
Wind Direction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watts / square centimeter
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SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
FRI 9 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
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Wind Speed
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Temperature
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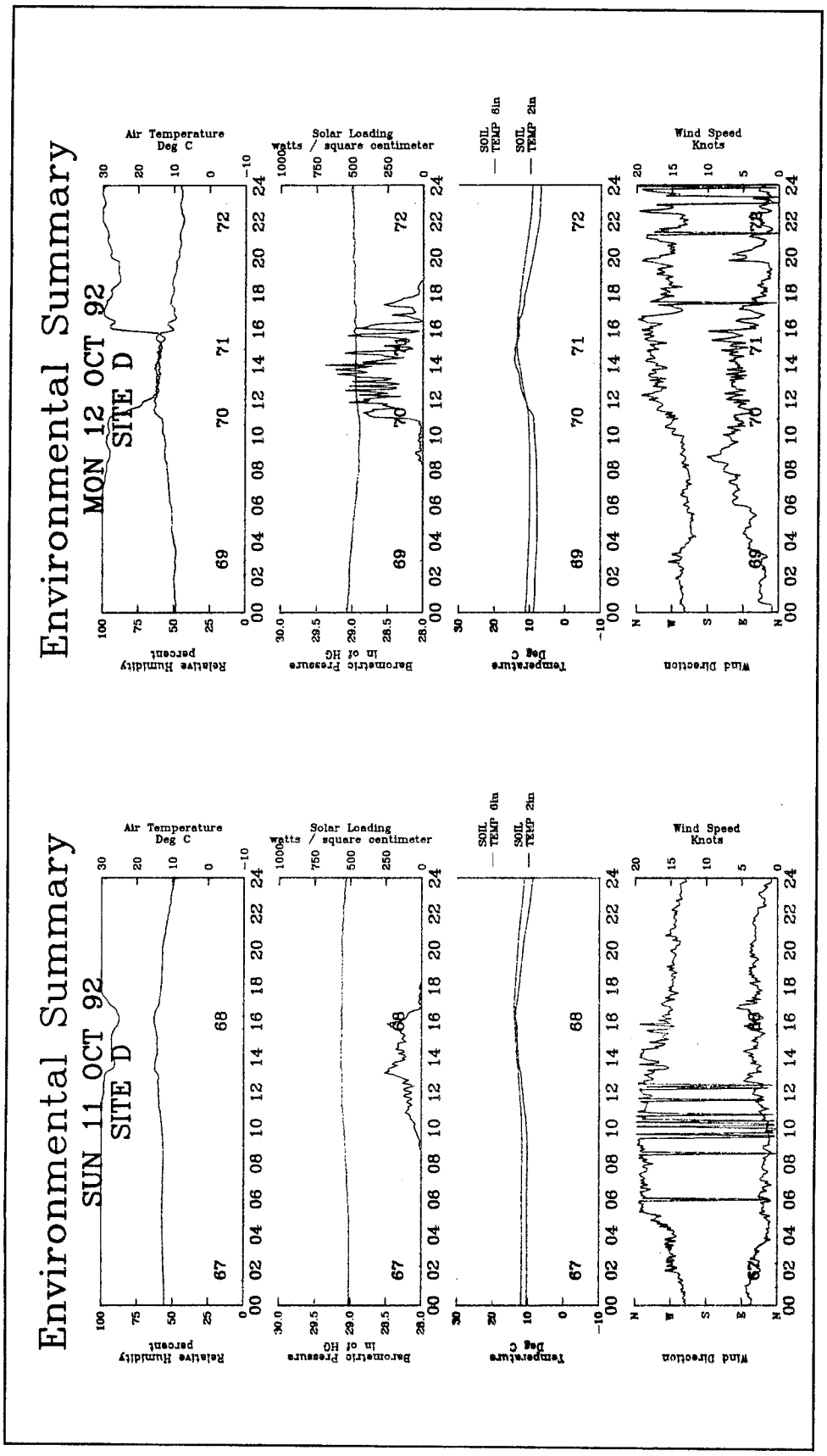
Wind Direction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watts / square centimeter
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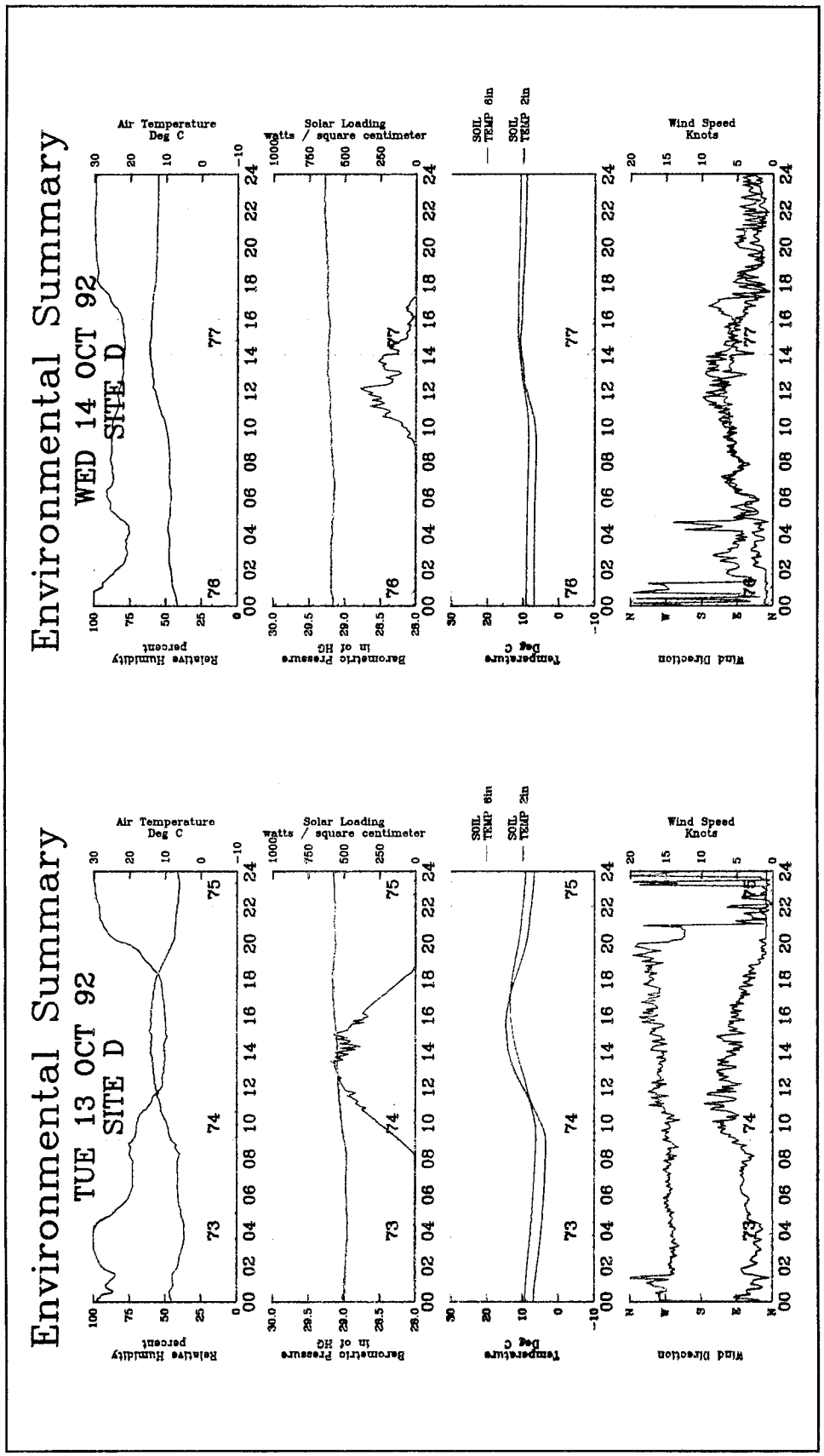
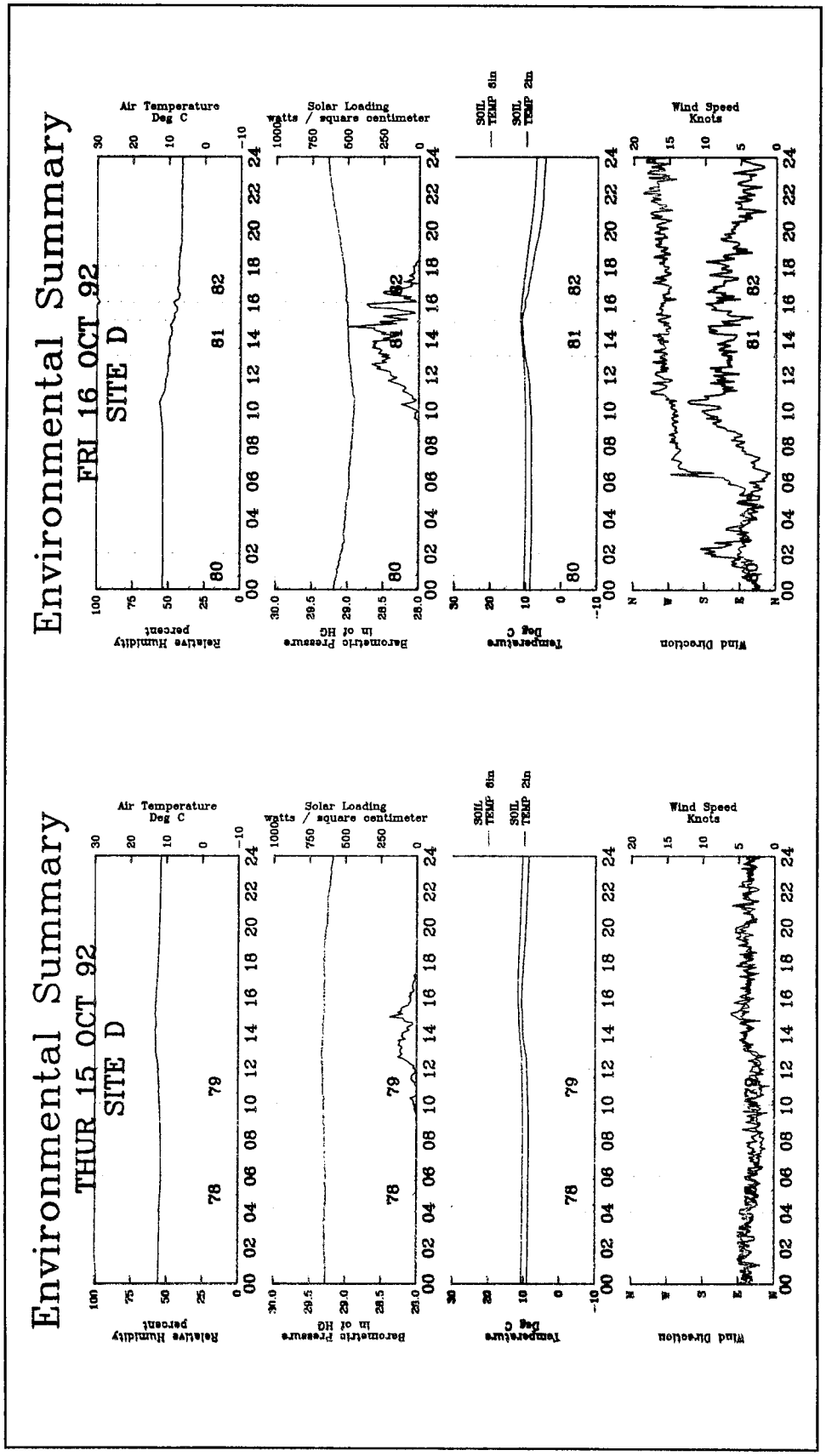
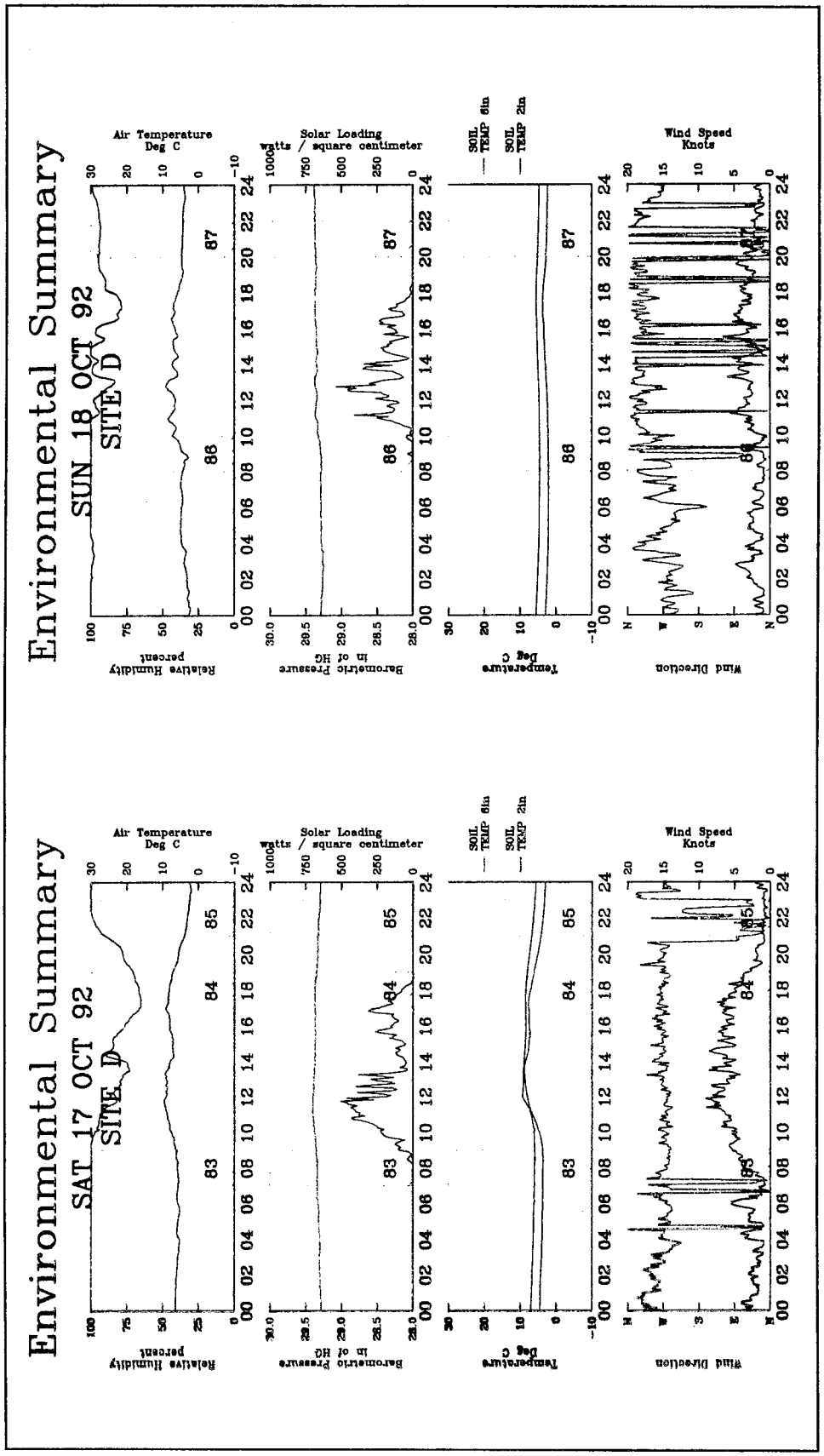
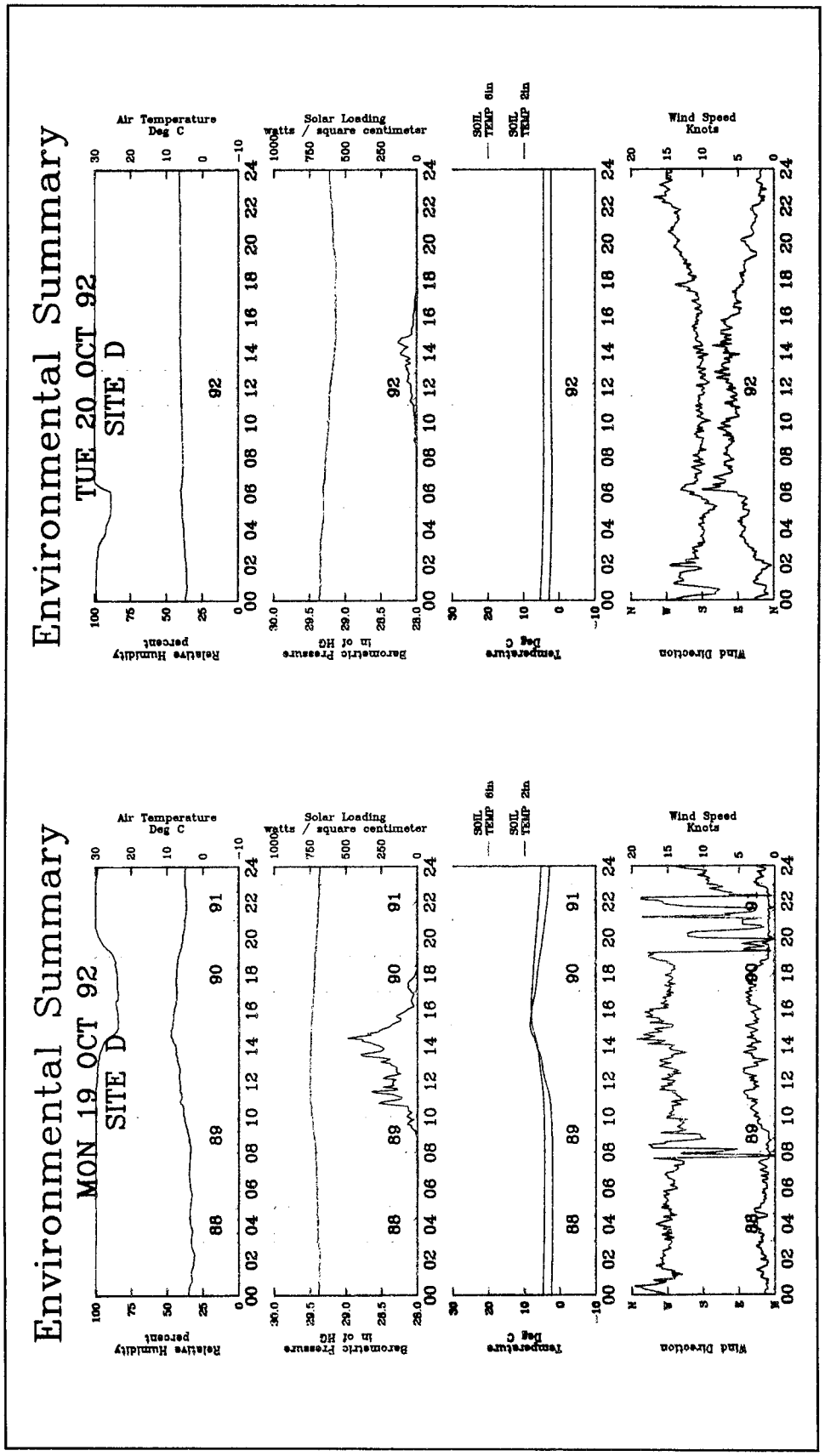
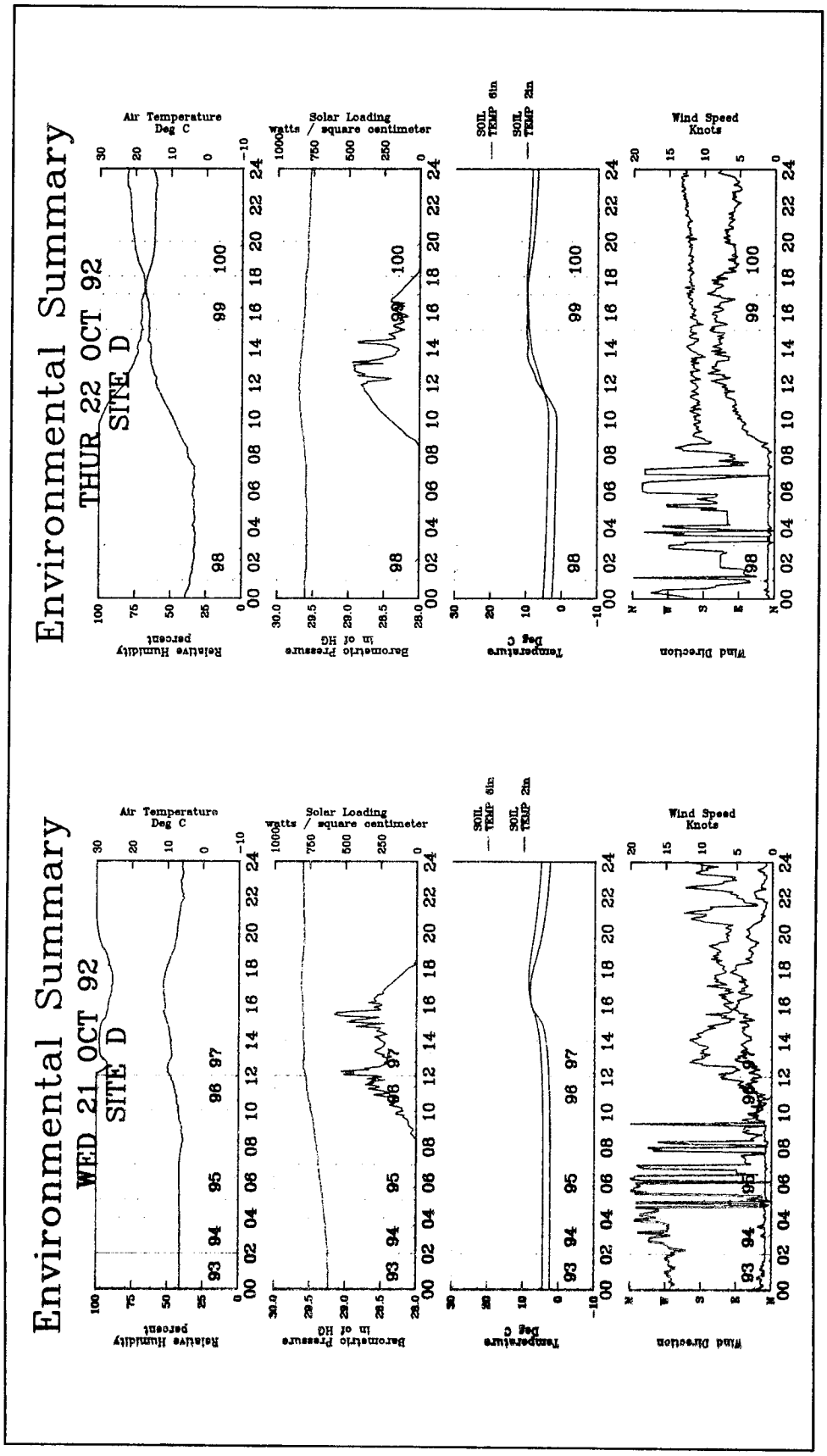
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction
Environmental Summary
SUN 11 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction

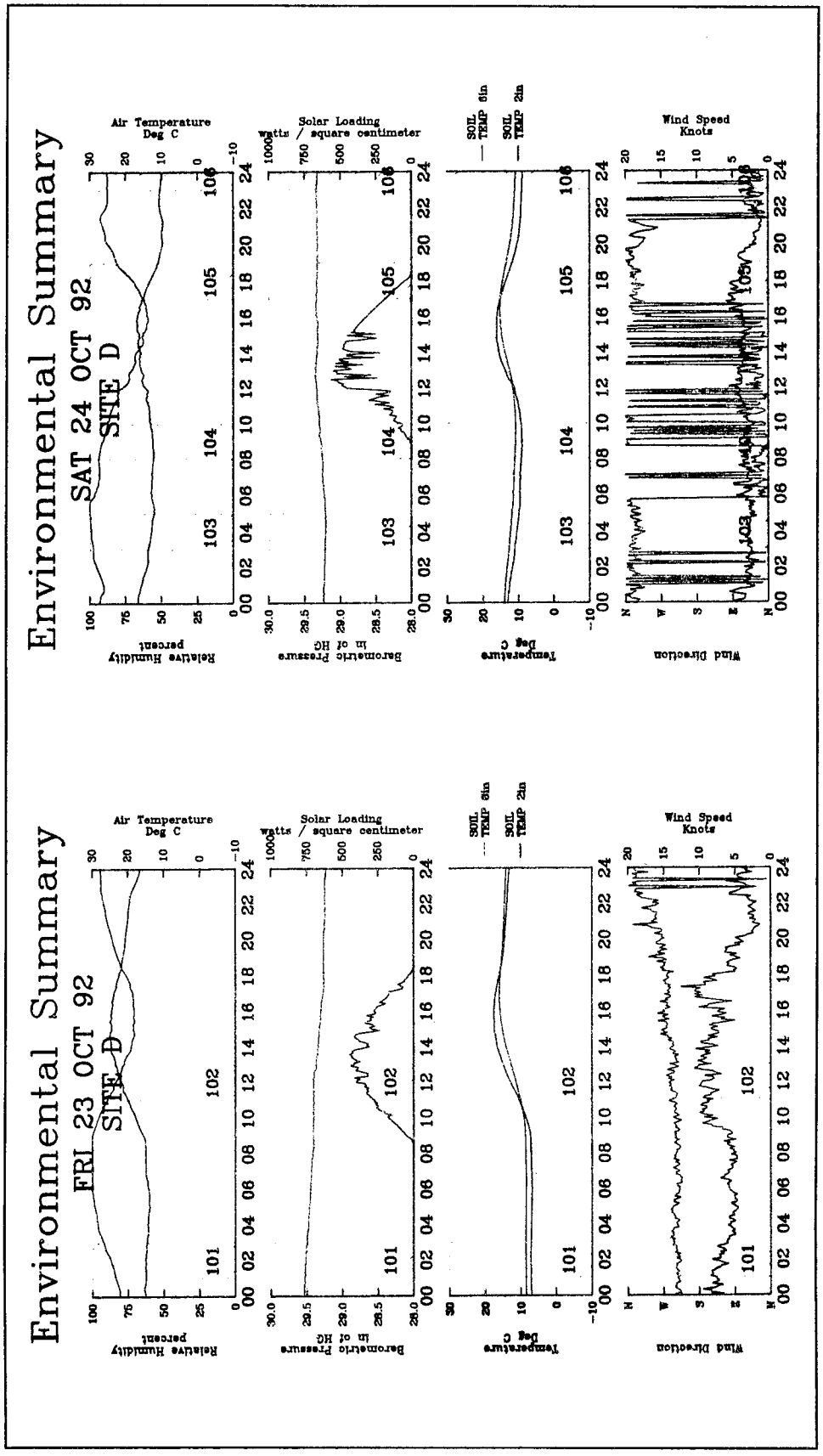

Environmental Summary
WED 14 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
TUE 13 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction

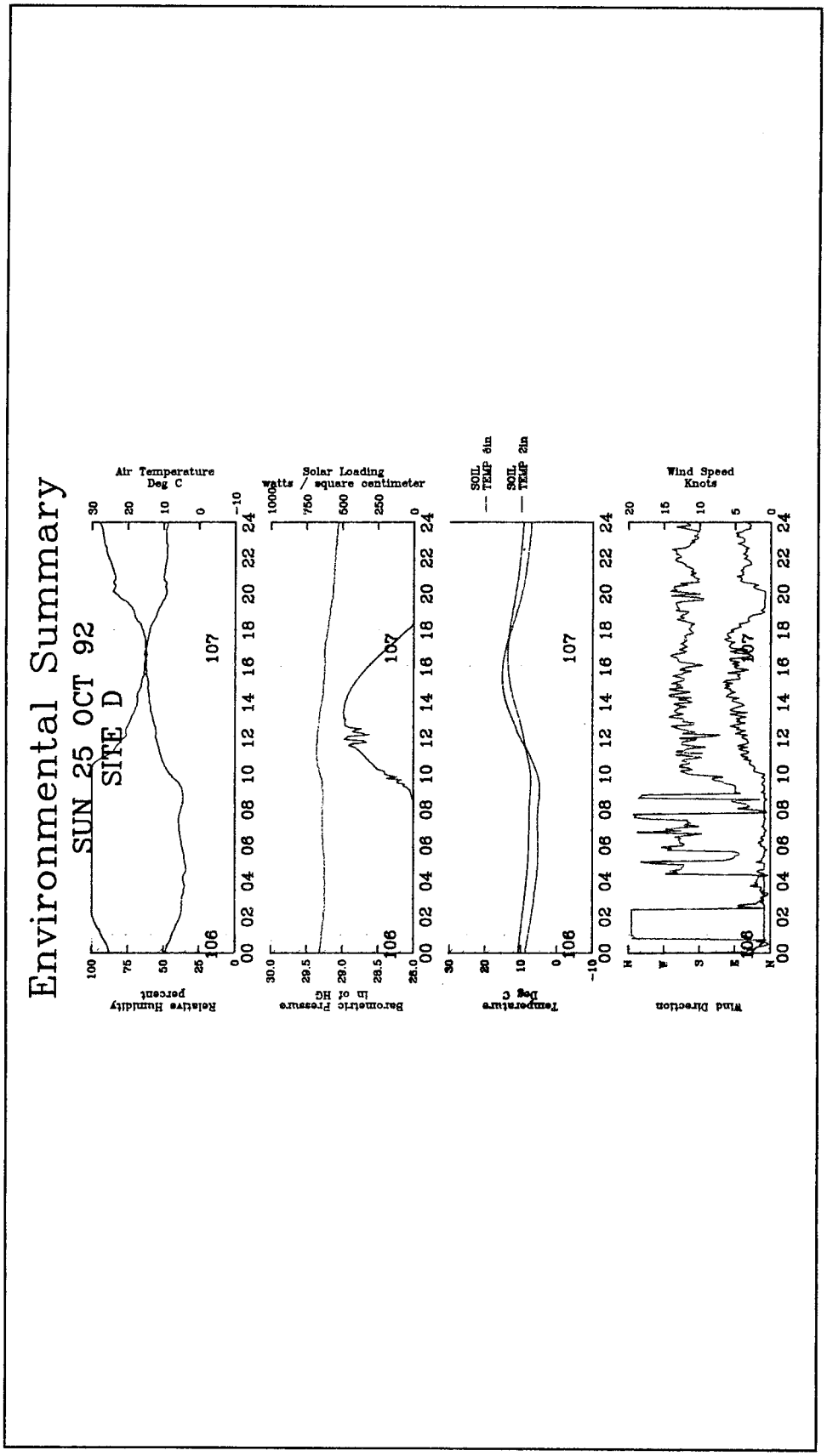

Environmental Summary
FRI 16 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
THUR 15 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction

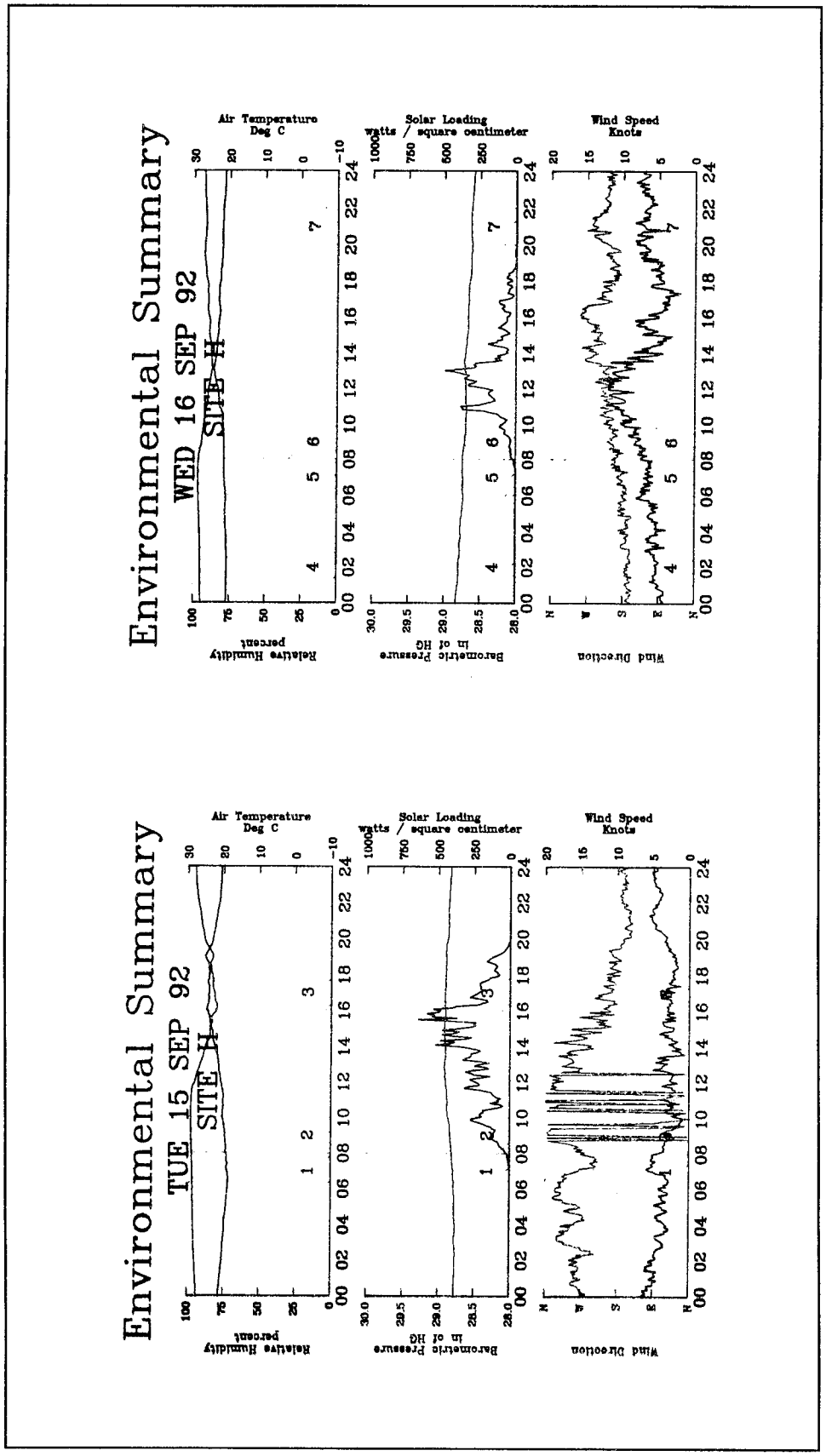

Environmental Summary
SUN 18 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction
Environmental Summary
SAT 17 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Temperature
Deg C
Wind Direction

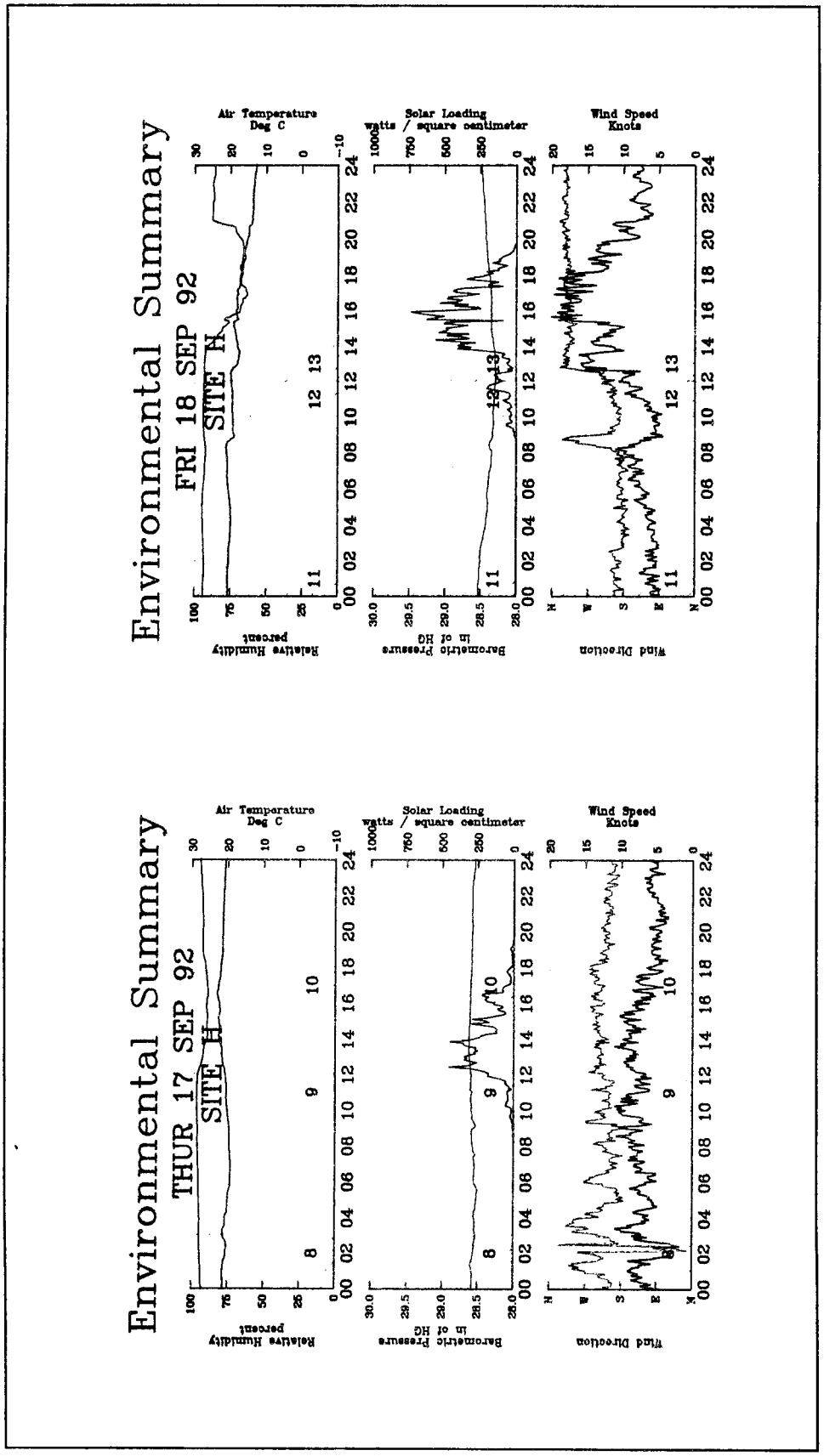

Environmental Summary
TUE 20 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
92
Environmental Summary
MON 19 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
88
89
90
91

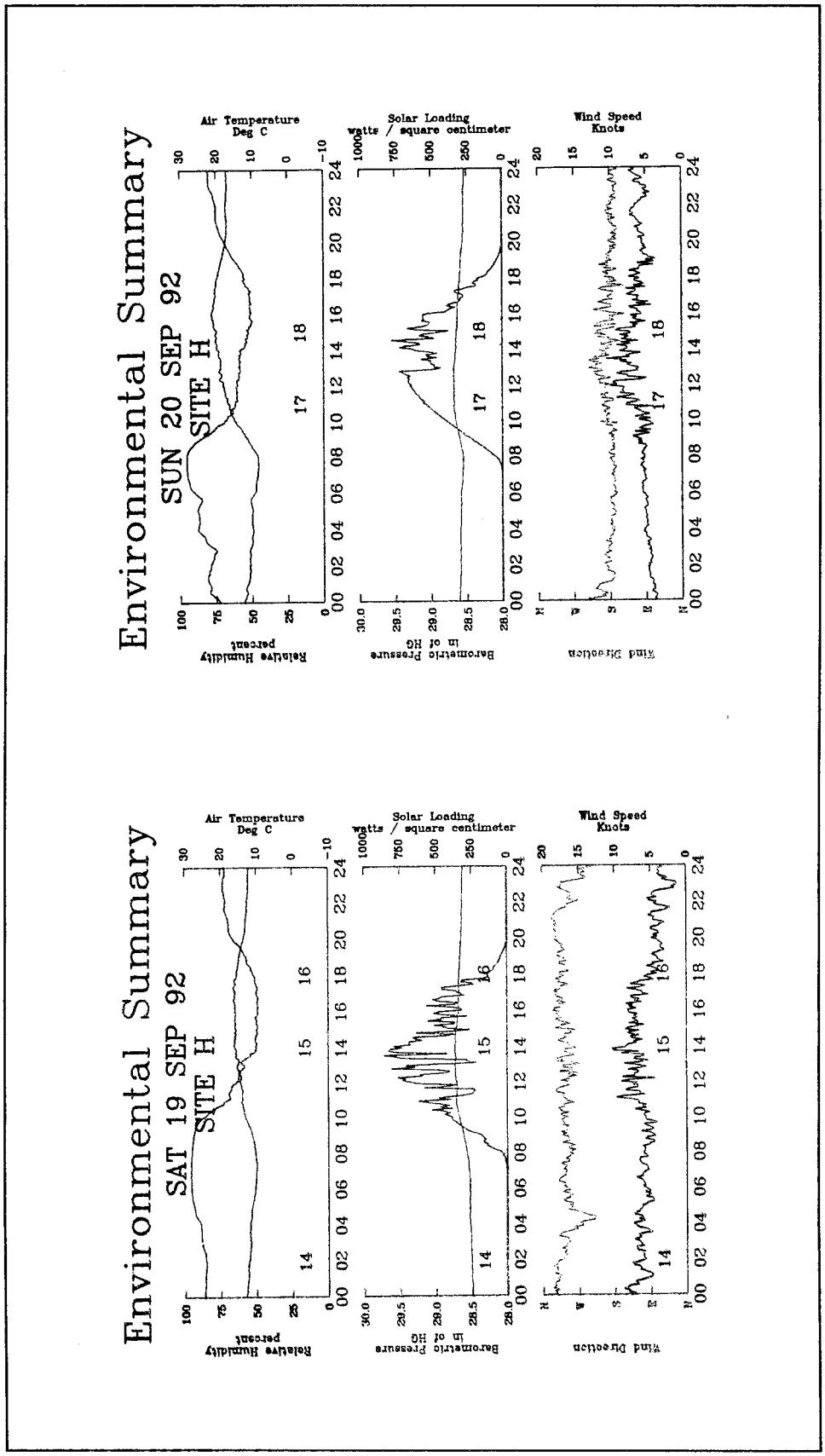

Environmental Summary
THUR 22 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
WED 21 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction

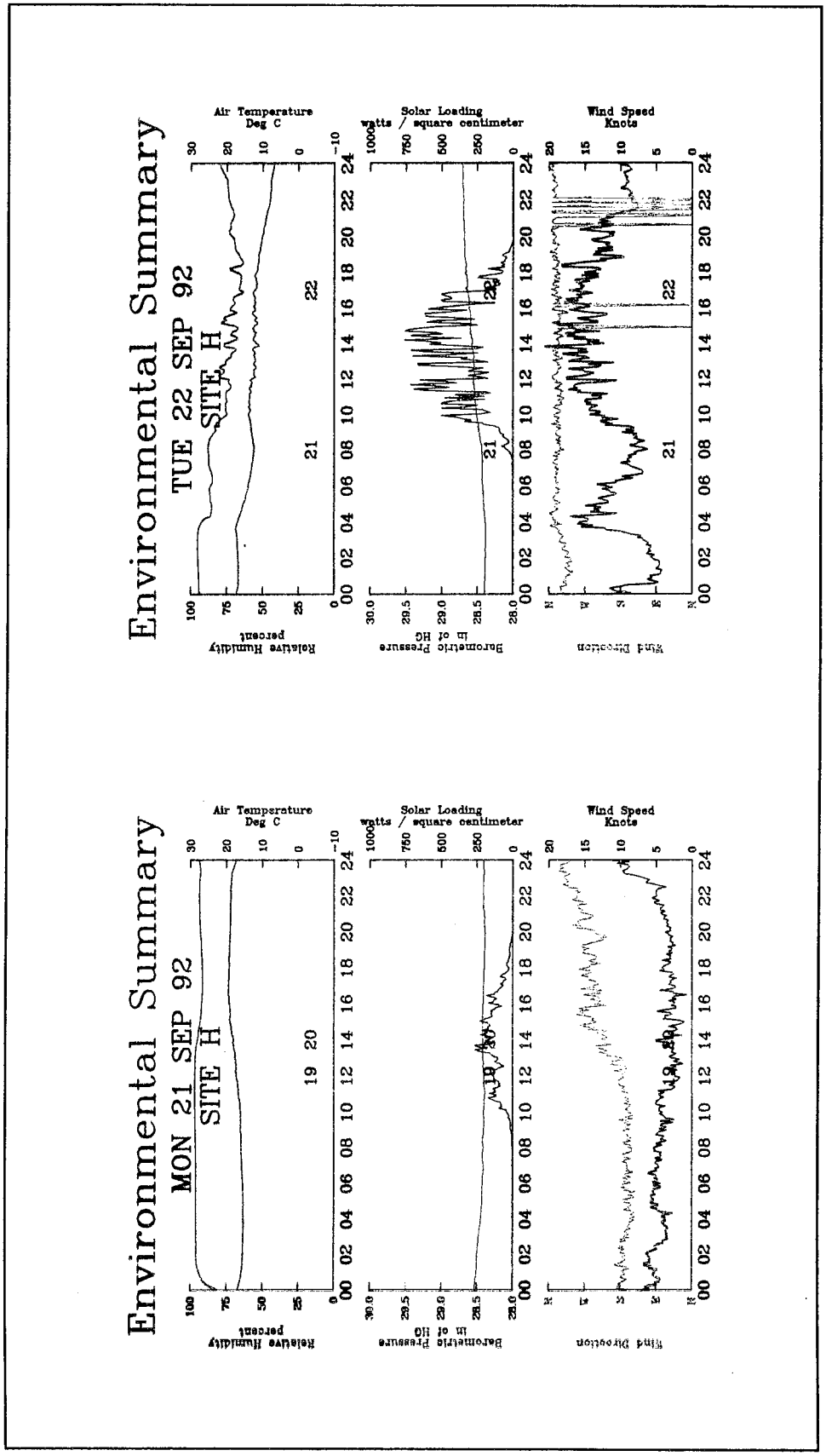

Environmental Summary
SAT 24 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction
Environmental Summary
FRI 23 OCT 92
SITE D
Air Temperature
Deg C
Solar Loading
watts / square centimeter
SOIL TEMP 6in
SOIL TEMP 2in
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Temperature
Deg C
Wind Direction

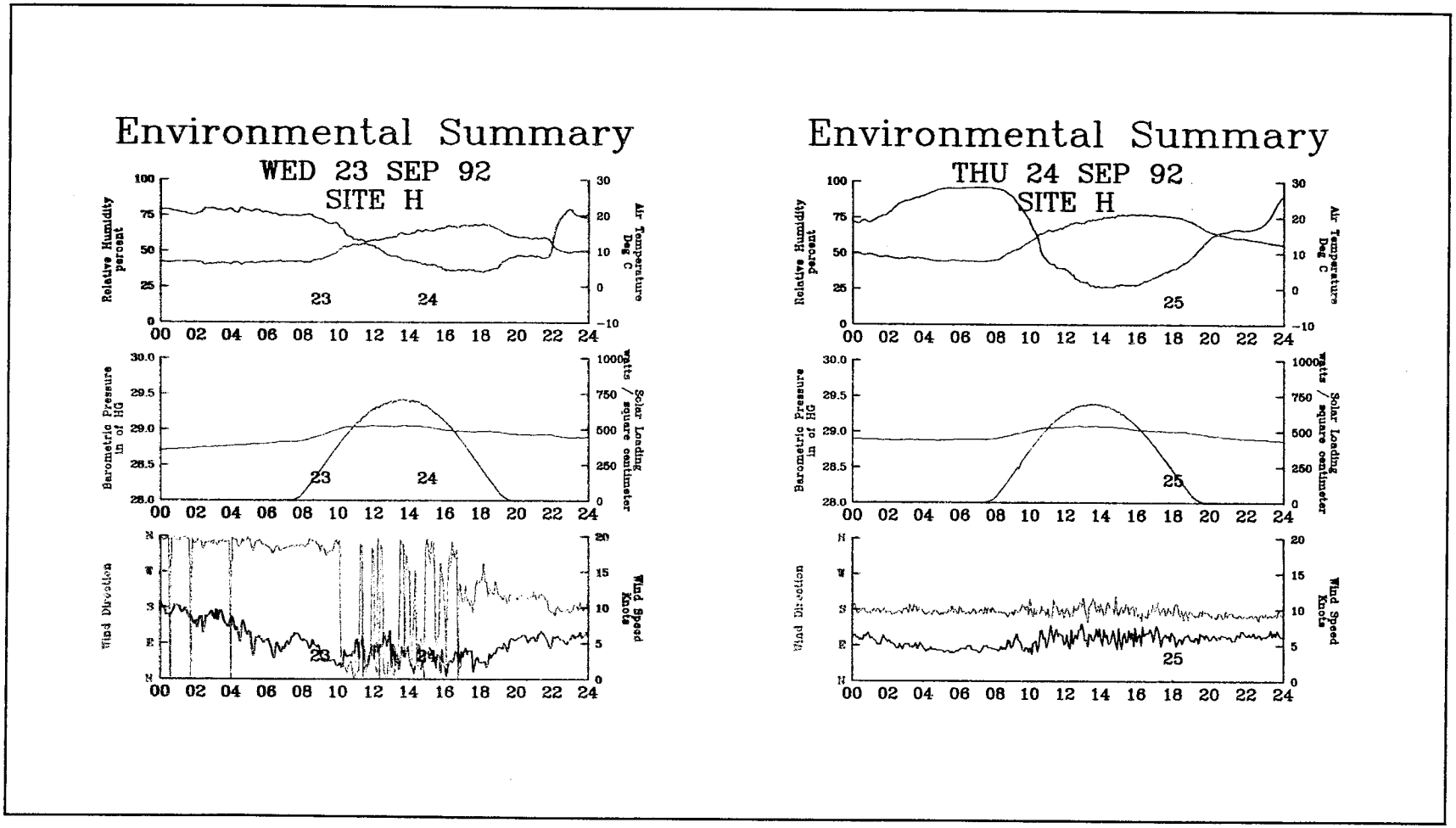

Environmental Summary
SUN 25 OCT 92
SITE D
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
SOIL TEMP 6in
SOIL TEMP 2in
Temperature
Deg C
Wind Speed
Knots
Wind Direction
106
107

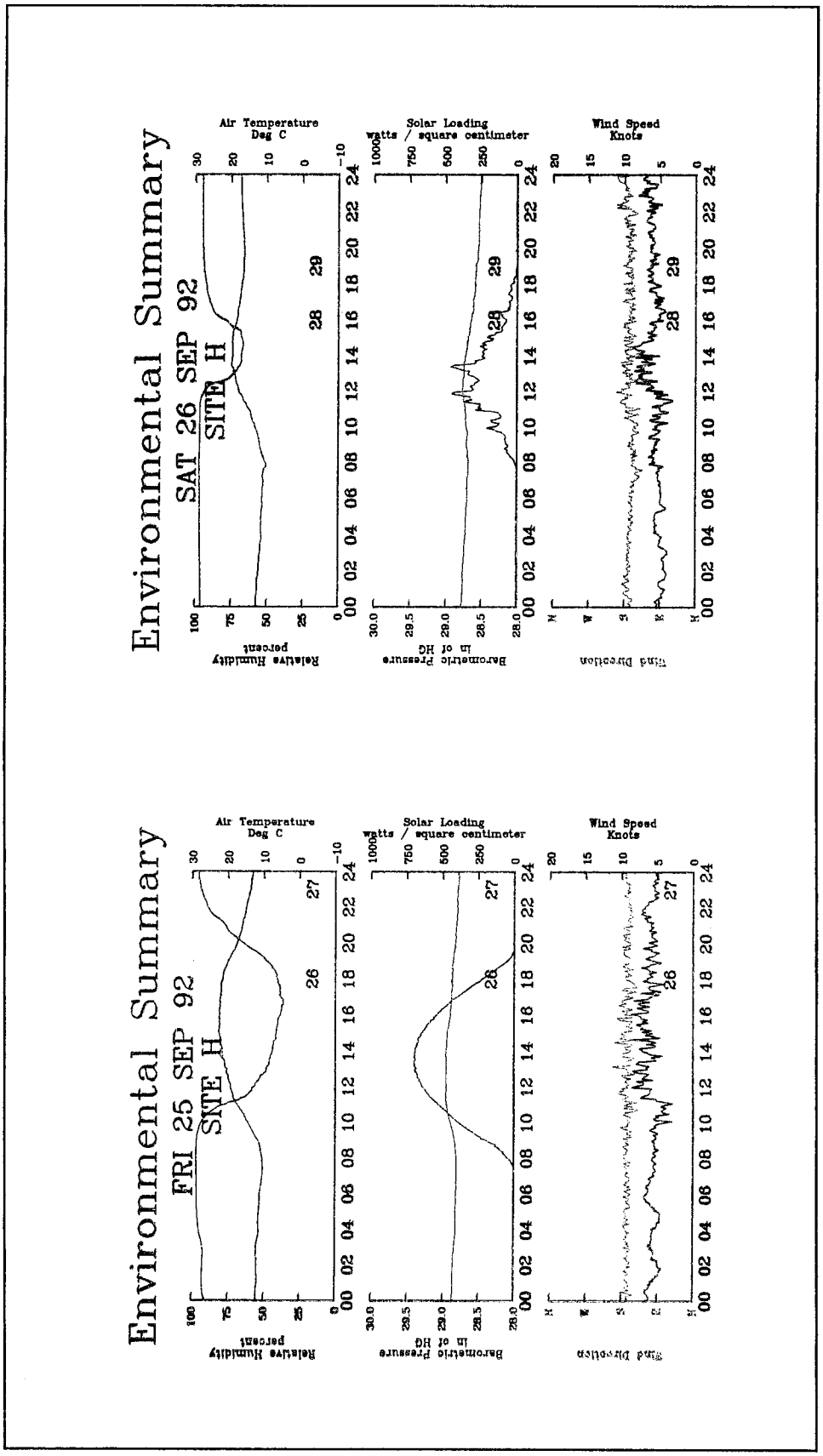

Environmental Summary
WED 16 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
TUE 15 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction

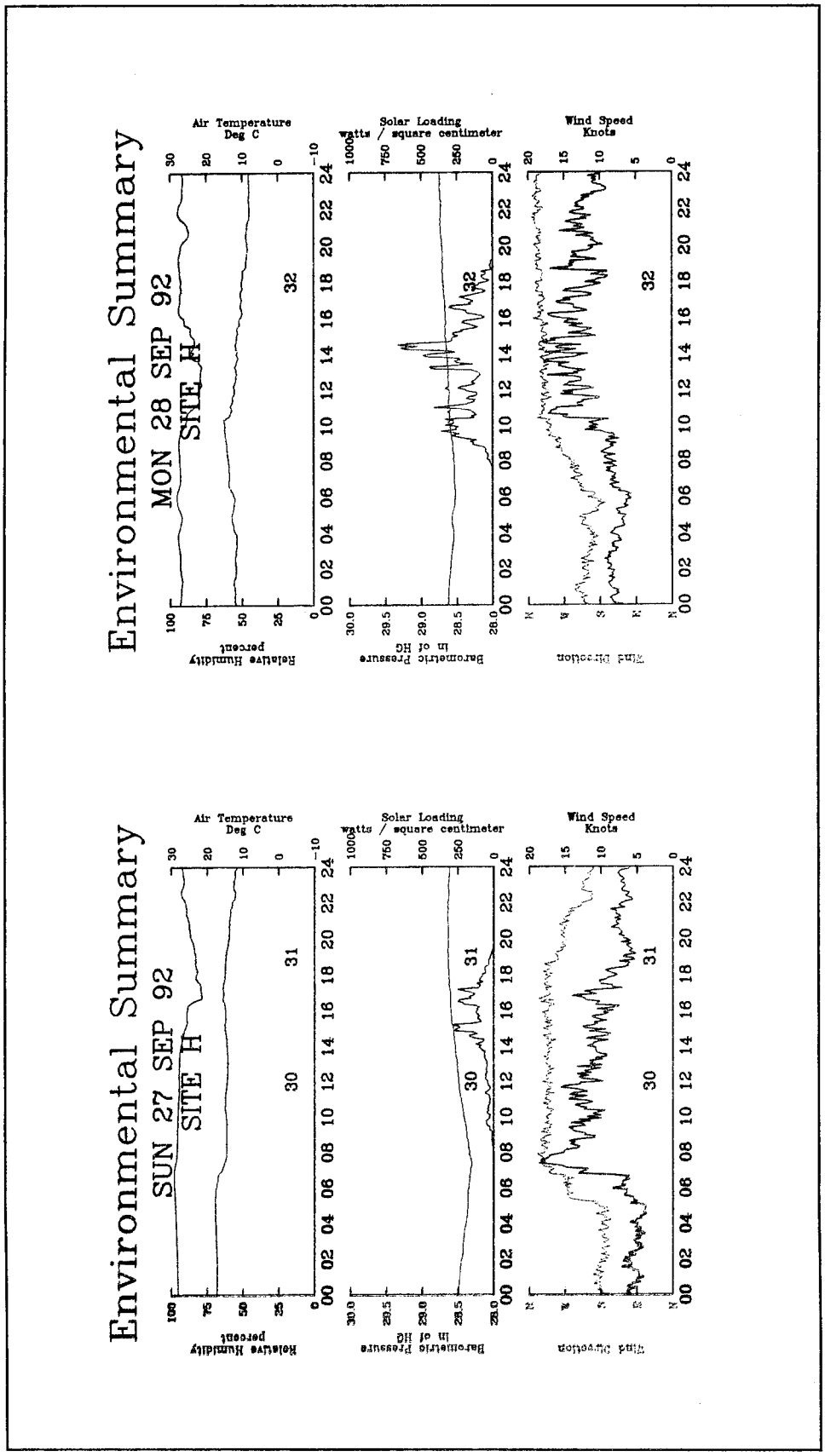

Environmental Summary
FRI 18 SEP 92
SITE N
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
Environmental Summary
THUR 17 SEP 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction

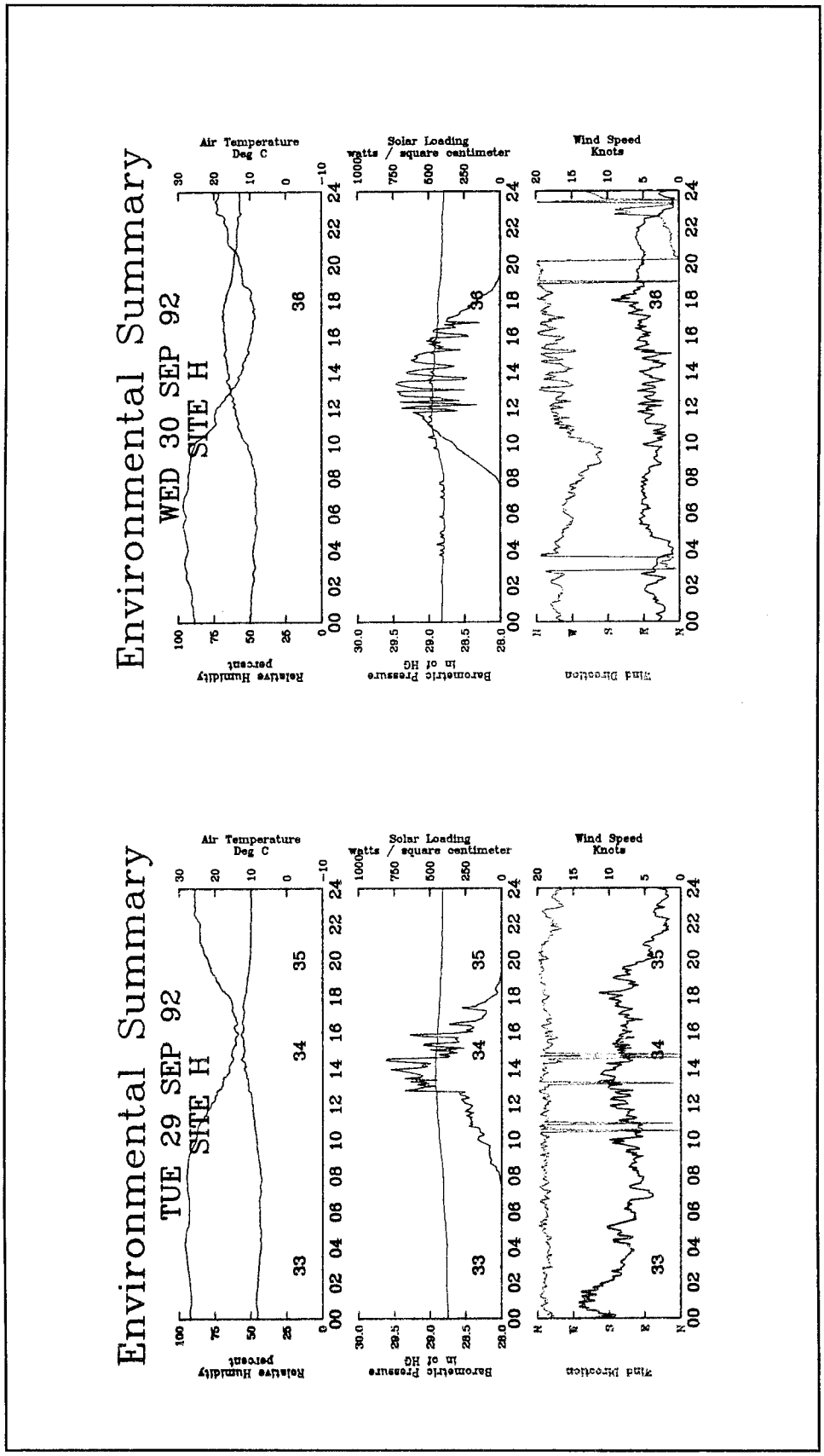

Environmental Summary
SUN 20 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
SAT 19 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction

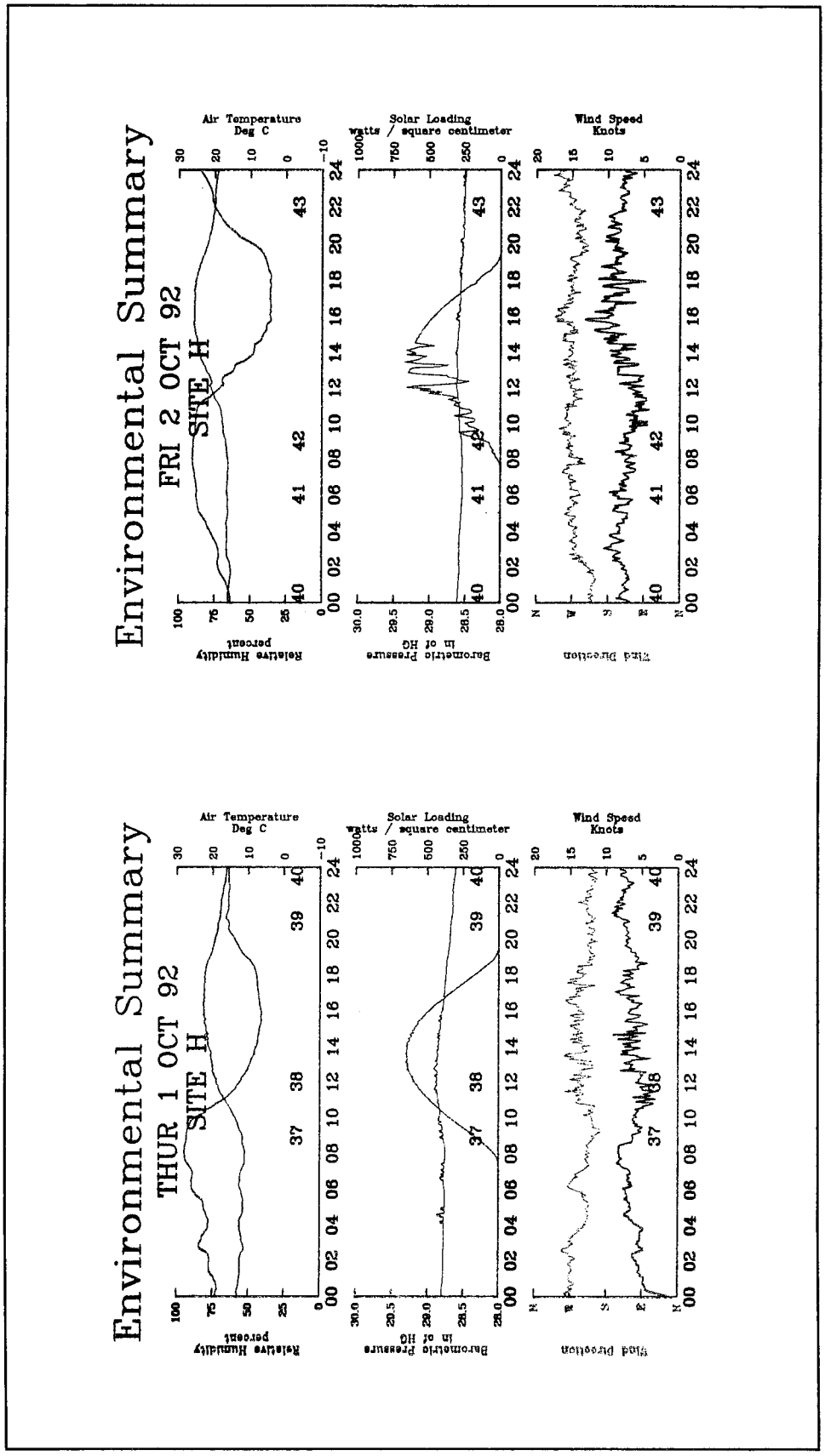

Environmental Summary
TUE 22 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
21
22
Environmental Summary
MON 21 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
19
20

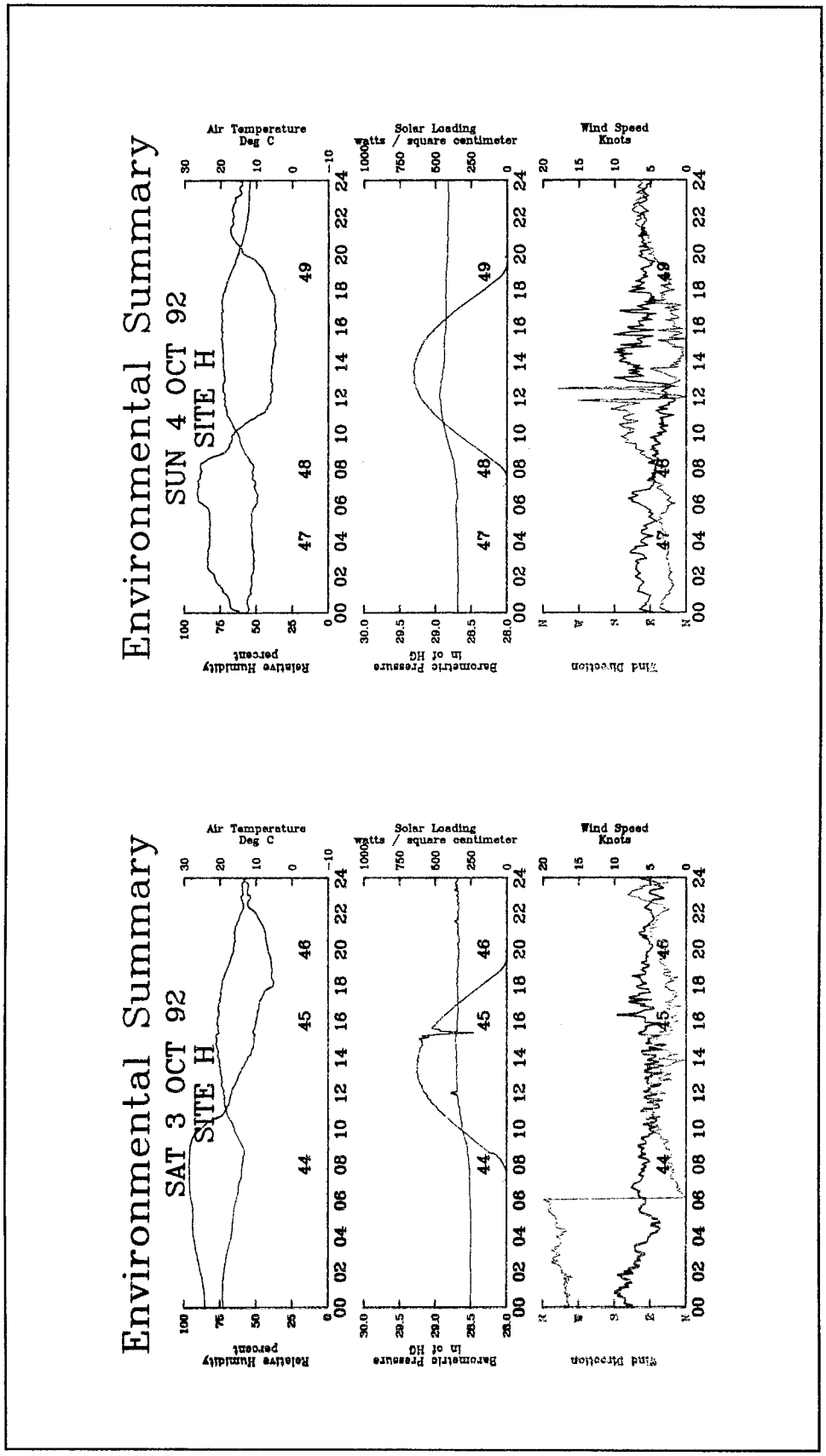

Environmental Summary
WED 23 SEP 92
SITE H
Relative Humidity percent
Air Temperature Deg C
Barometric Pressure in of HG
Solar Loading watts / square centimeter
Wind Direction
Wind Speed Knots
23
24
00 02 04 06 08 10 12 14 16 18 20 22 24
Environmental Summary
THU 24 SEP 92
SITE H
Relative Humidity percent
Air Temperature Deg C
Barometric Pressure in of HG
Solar Loading watts / square centimeter
Wind Direction
Wind Speed Knots
25
00 02 04 06 08 10 12 14 16 18 20 22 24

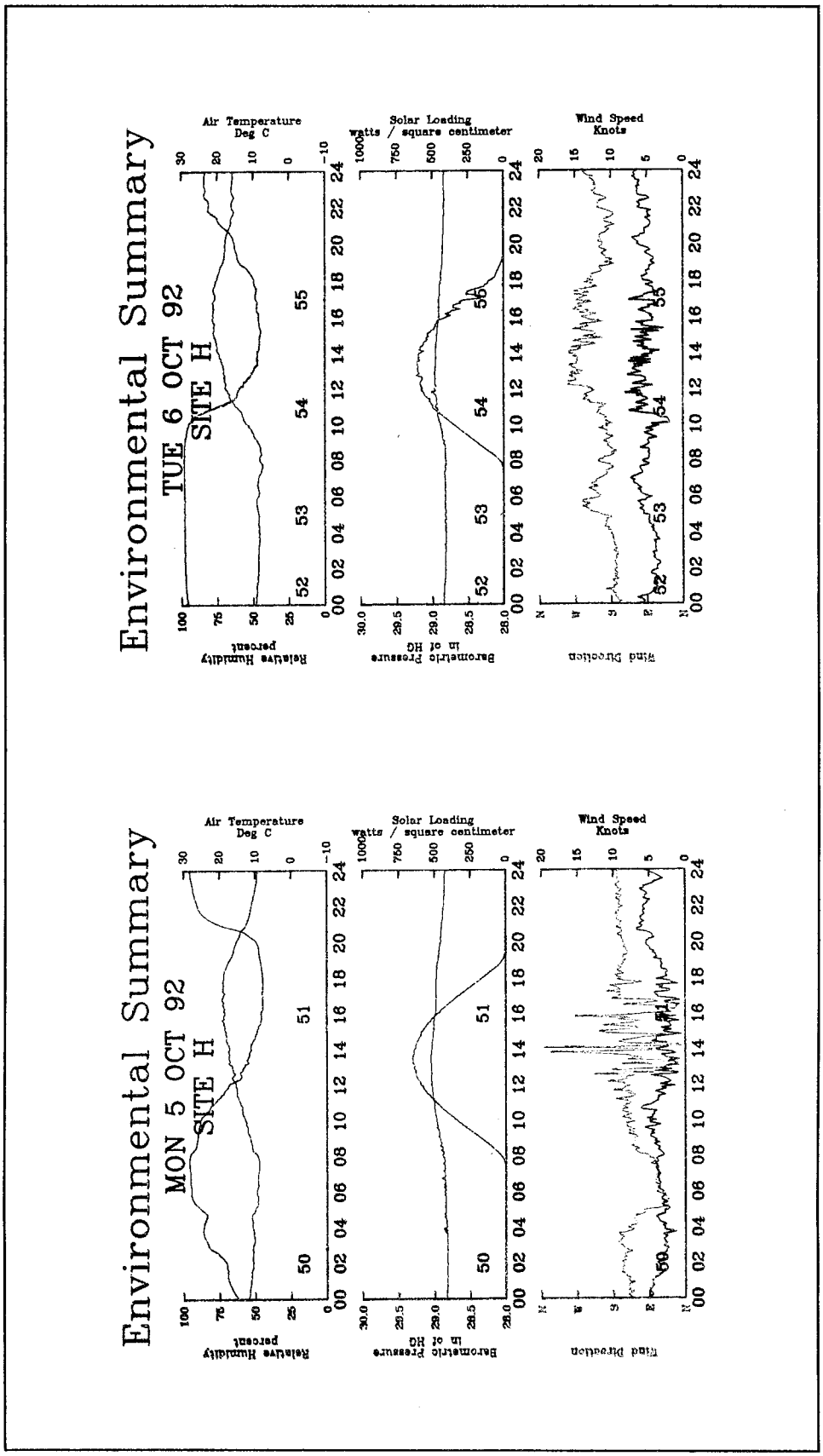

Environmental Summary
SAT 26 SEP 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction
Environmental Summary
FRI 25 SEP 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction

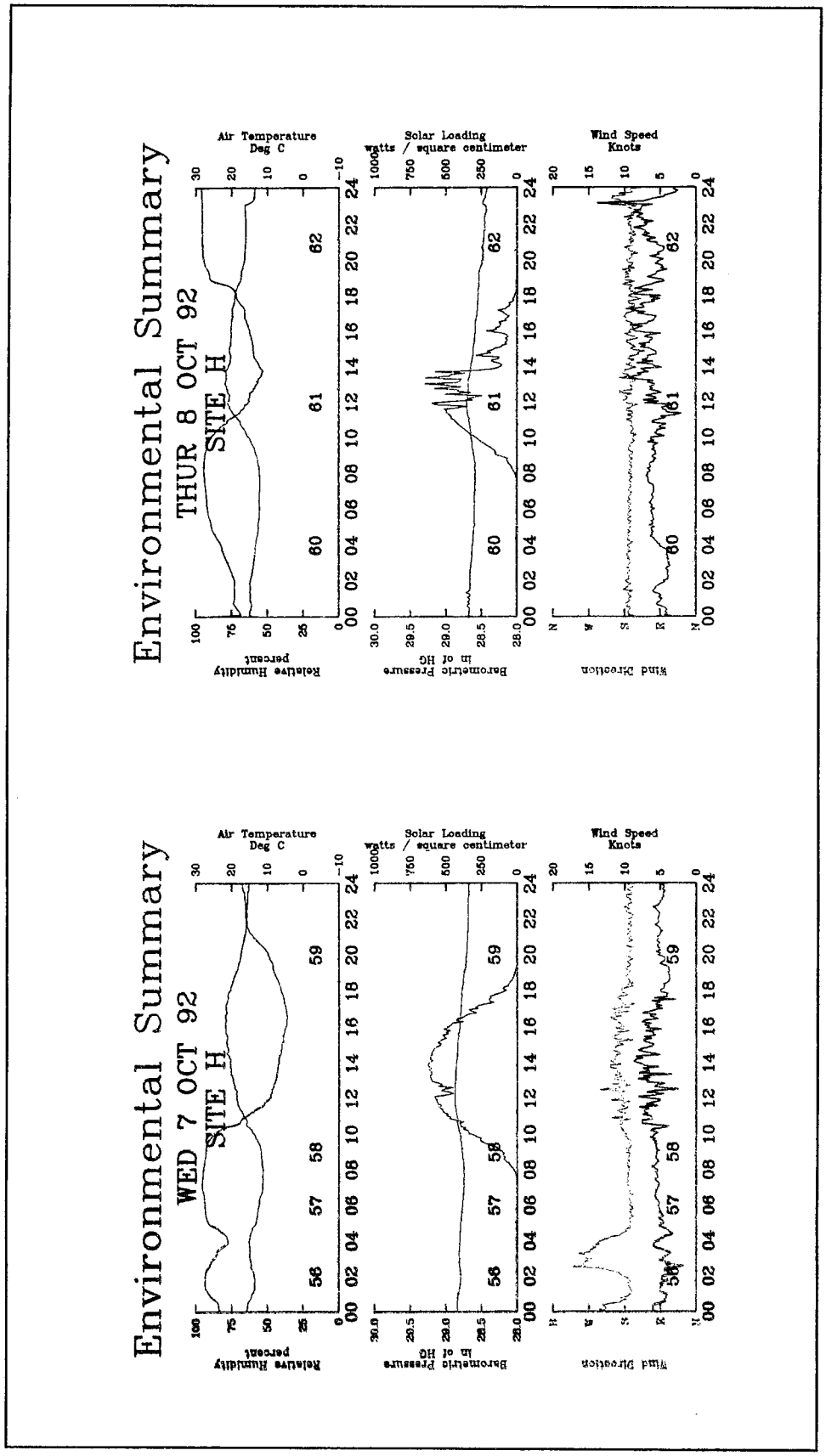

Environmental Summary
MON 28 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
32
Environmental Summary
SUN 27 SEP 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
30
31

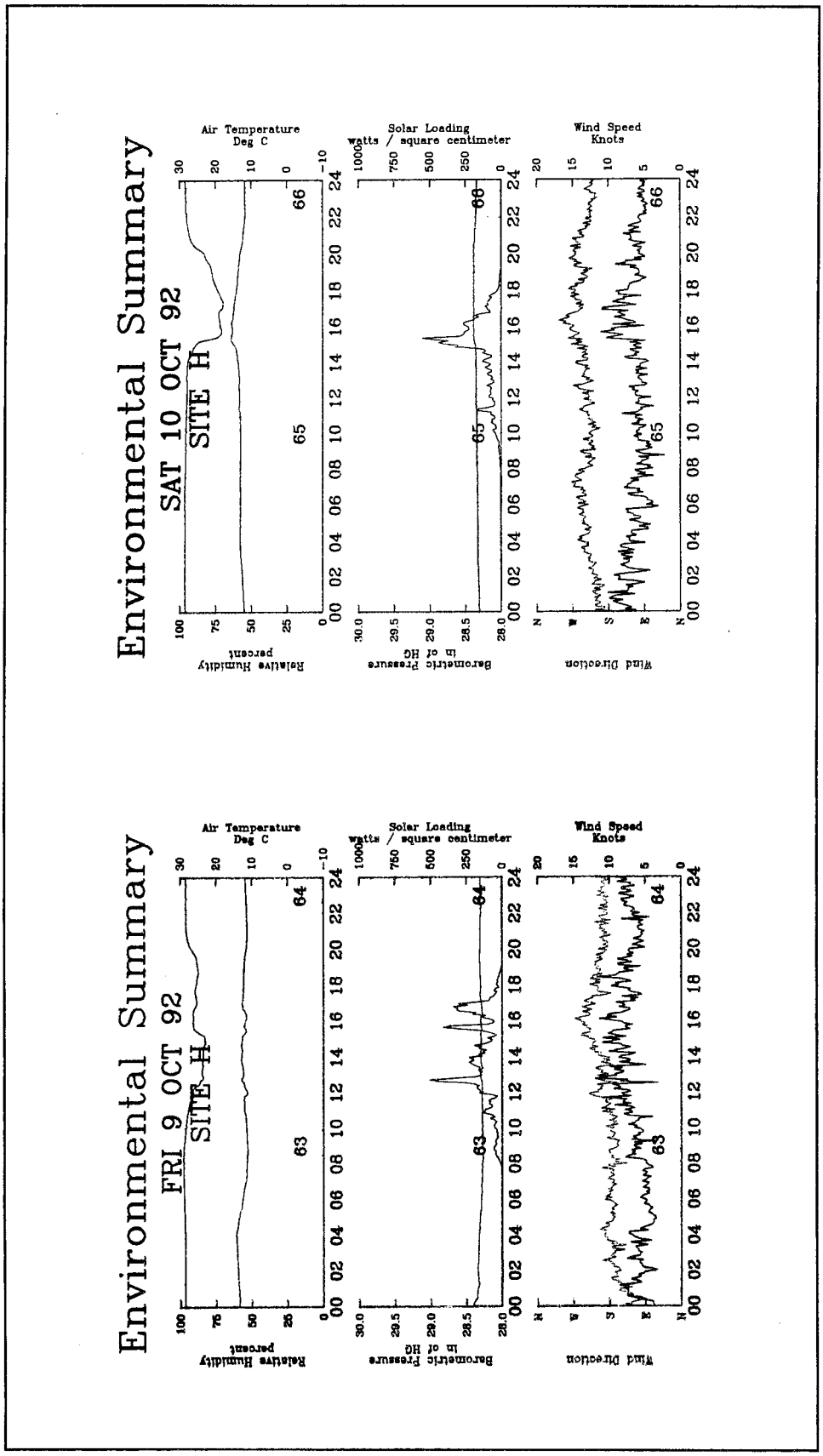

Environmental Summary
WED 30 SEP 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
36
Environmental Summary
TUE 29 SEP 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
33
34
35

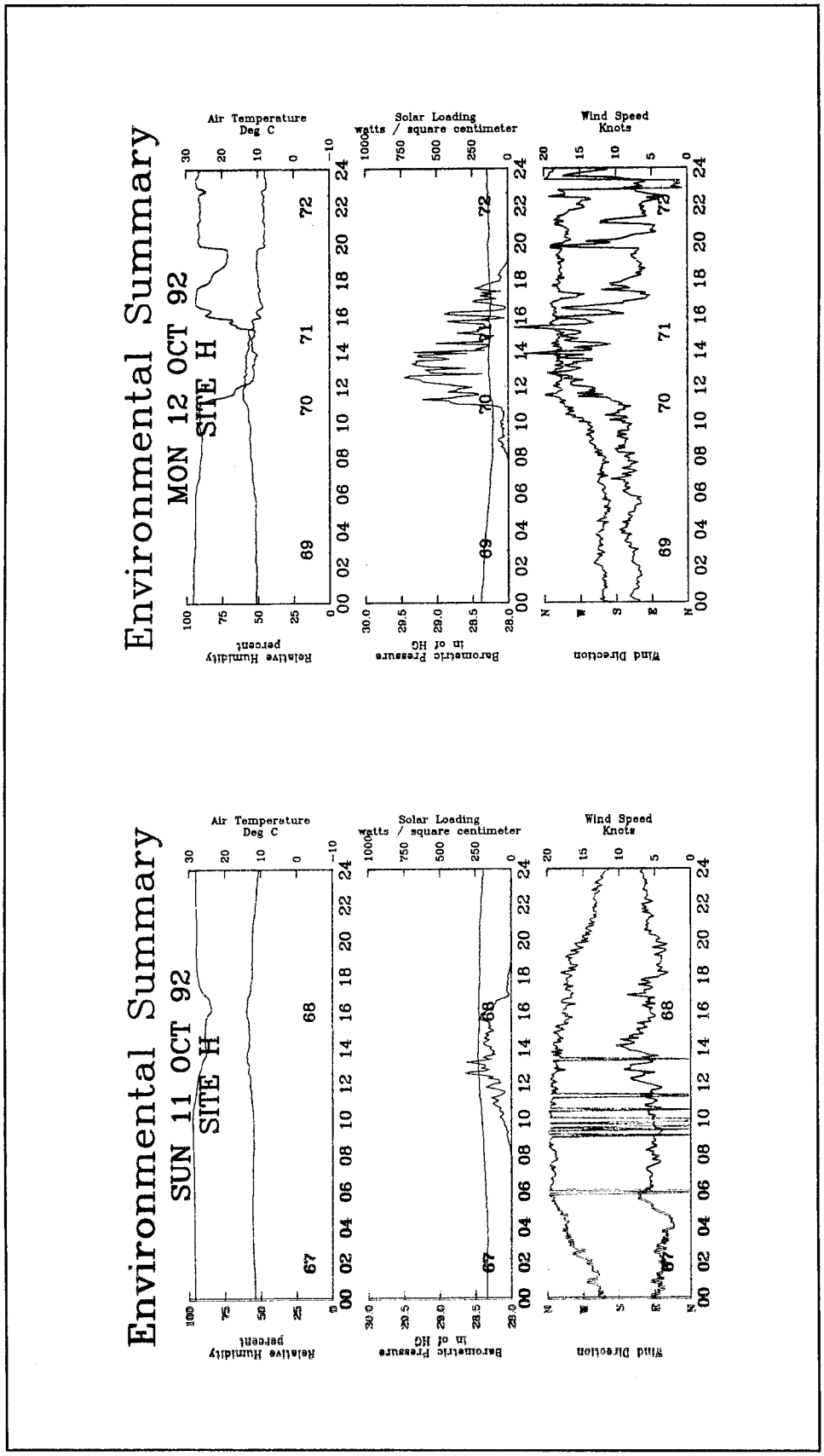

Environmental Summary
FRI 2 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
THUR 1 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction

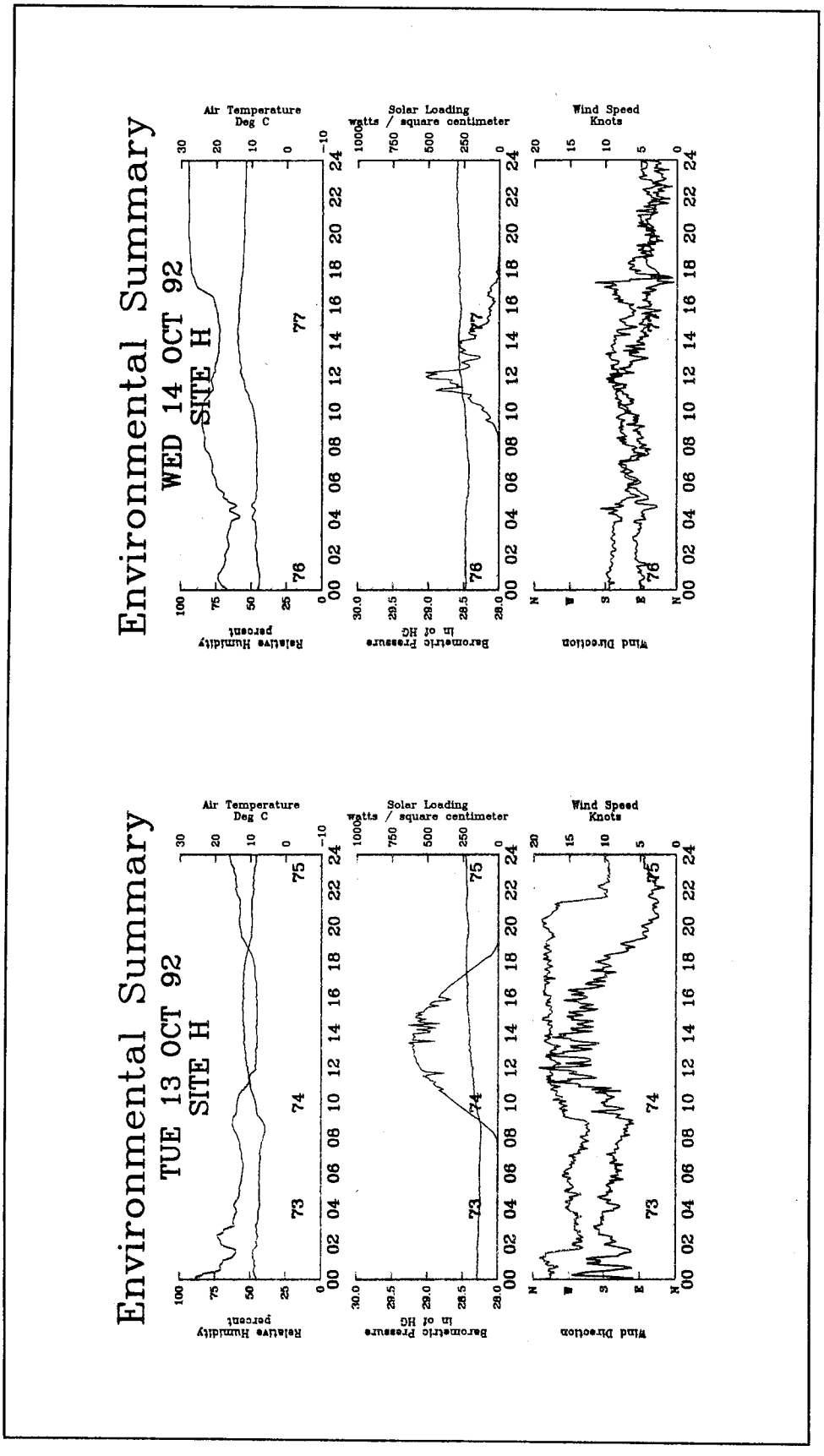

Environmental Summary
SUN 4 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
SAT 3 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction

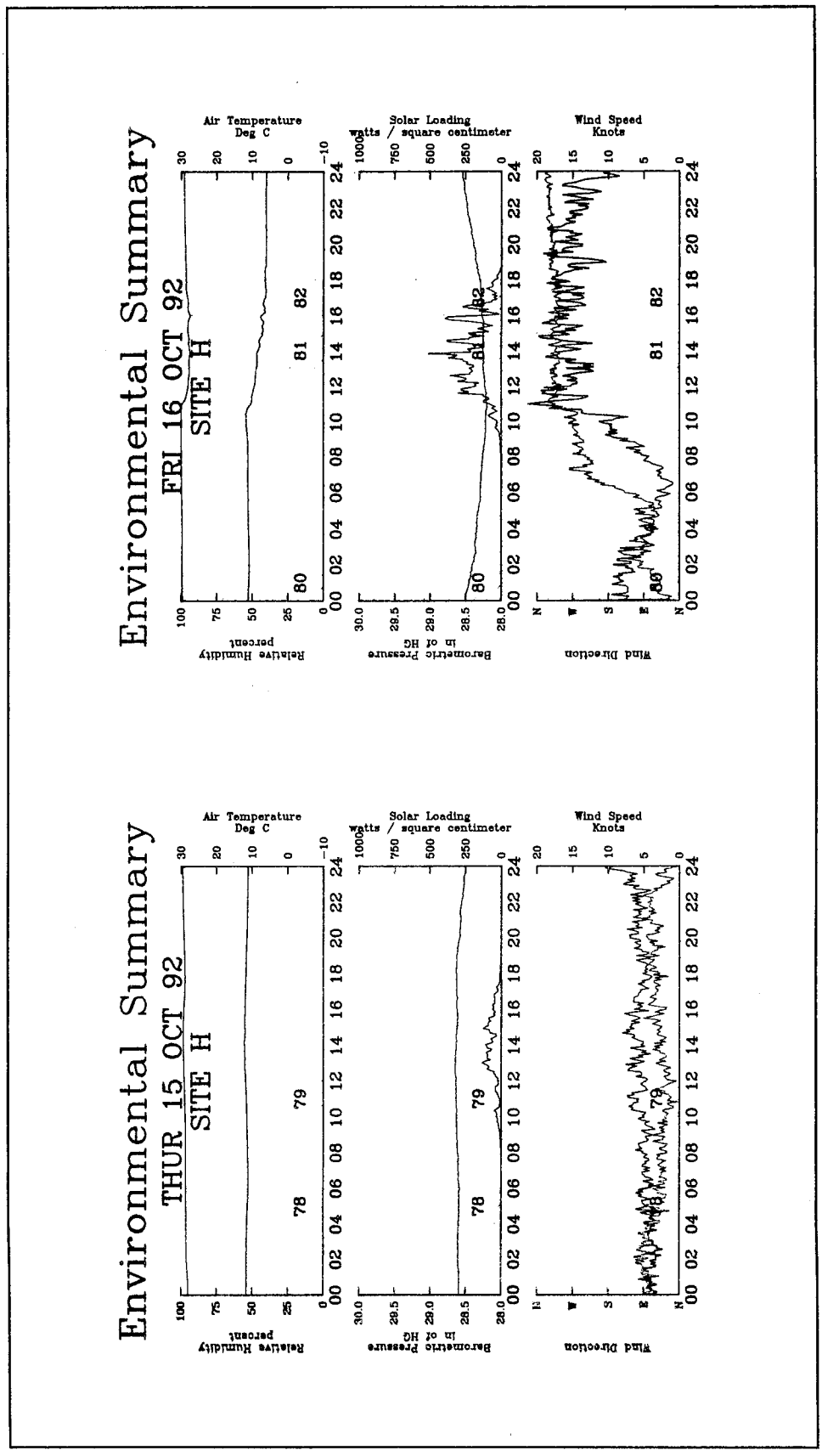

Environmental Summary
TUE 6 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
Environmental Summary
MON 5 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction

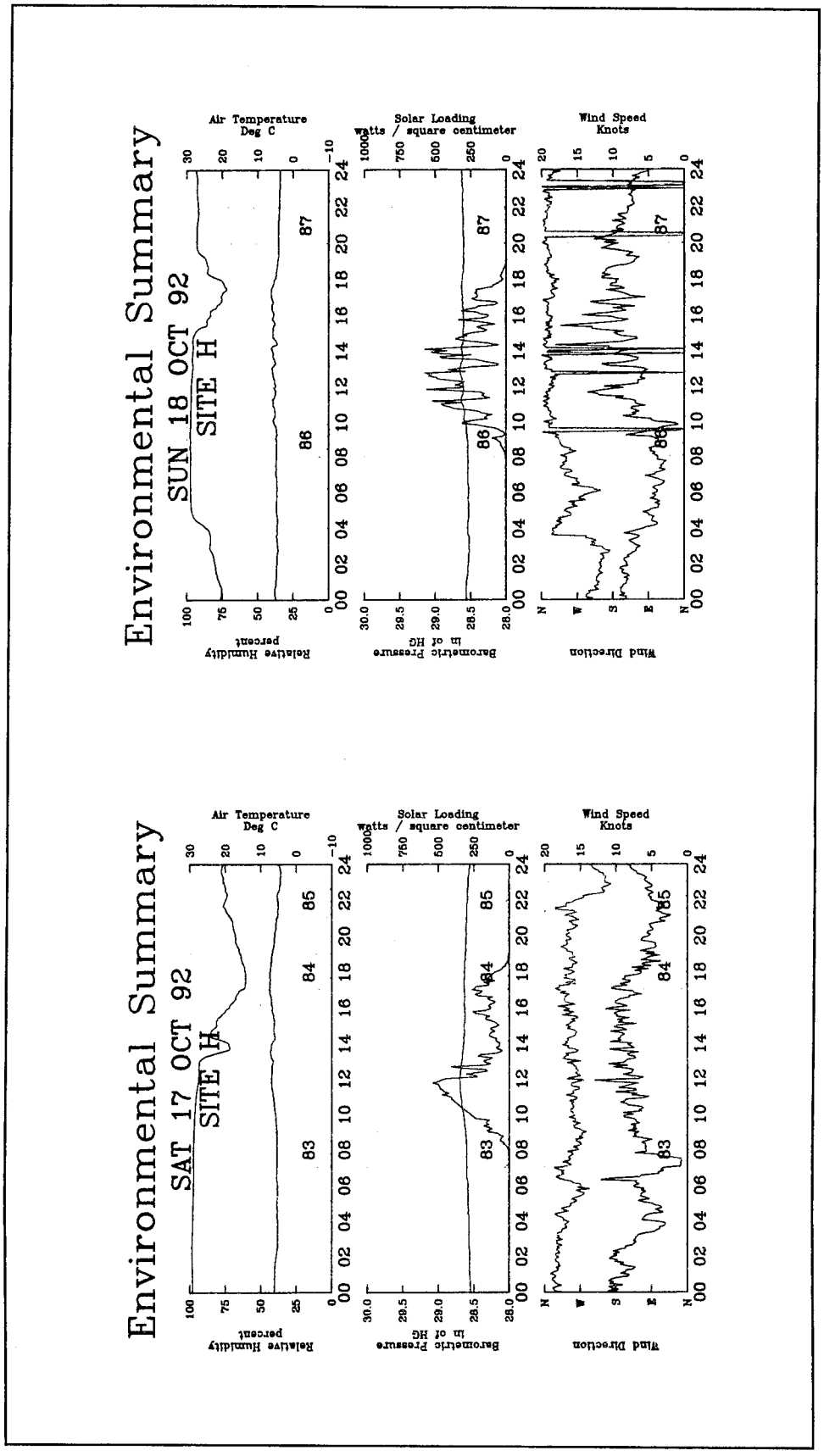

Environmental Summary
THUR 8 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction
Environmental Summary
WED 7 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction

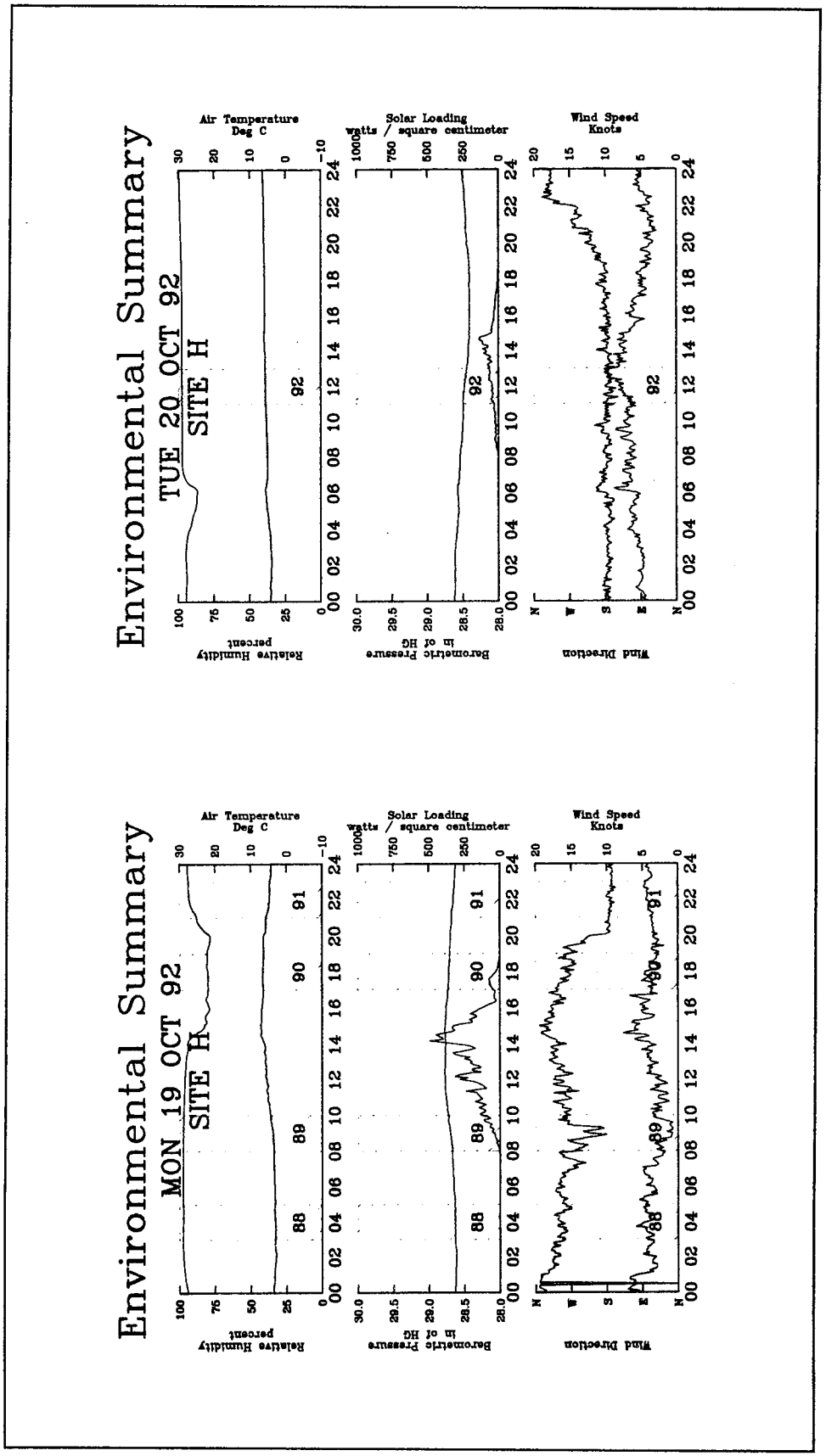

Environmental Summary
SAT 10 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
Environmental Summary
FRI 9 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction

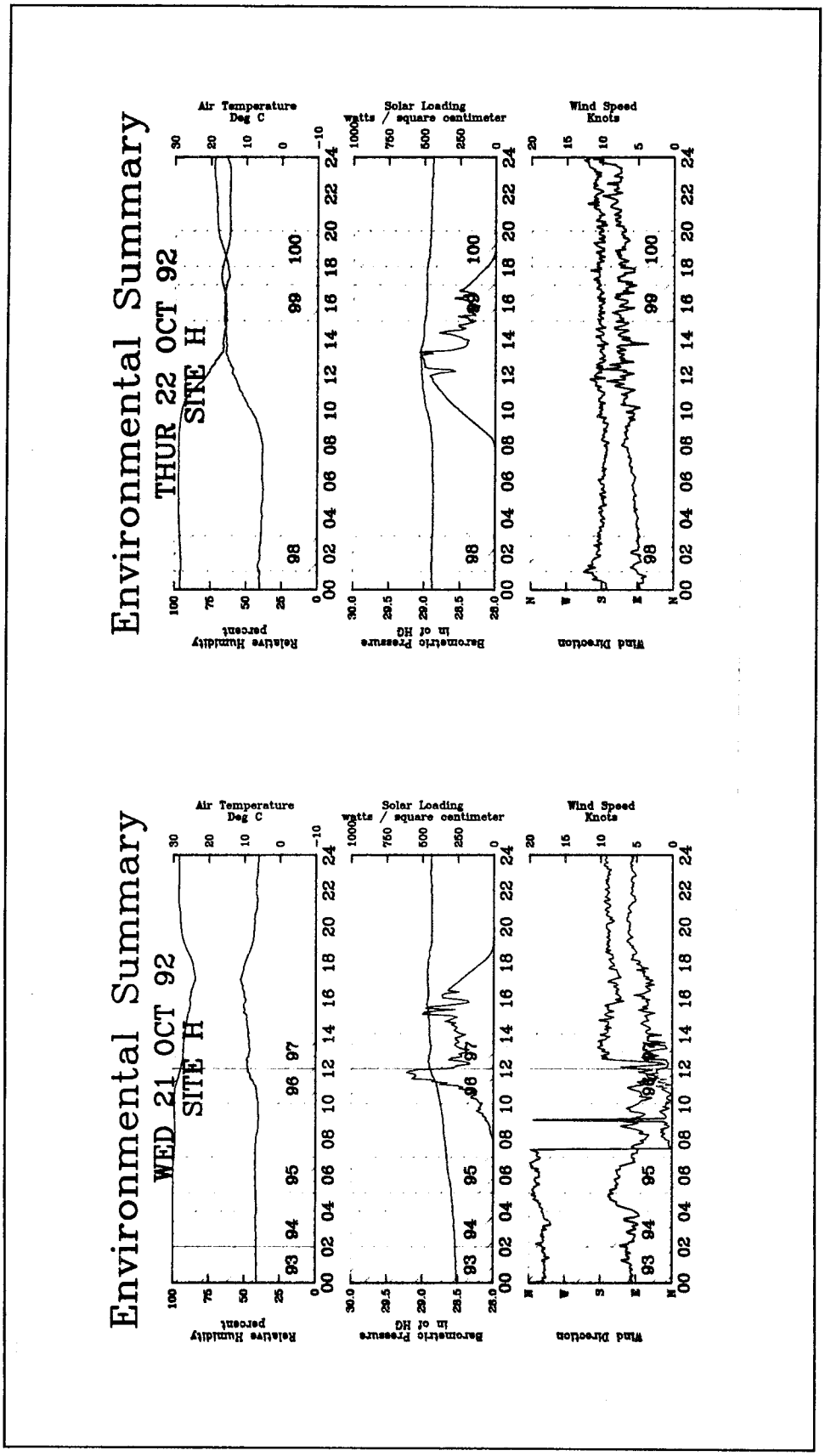

Environmental Summary
MON 12 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
Environmental Summary
SUN 11 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction

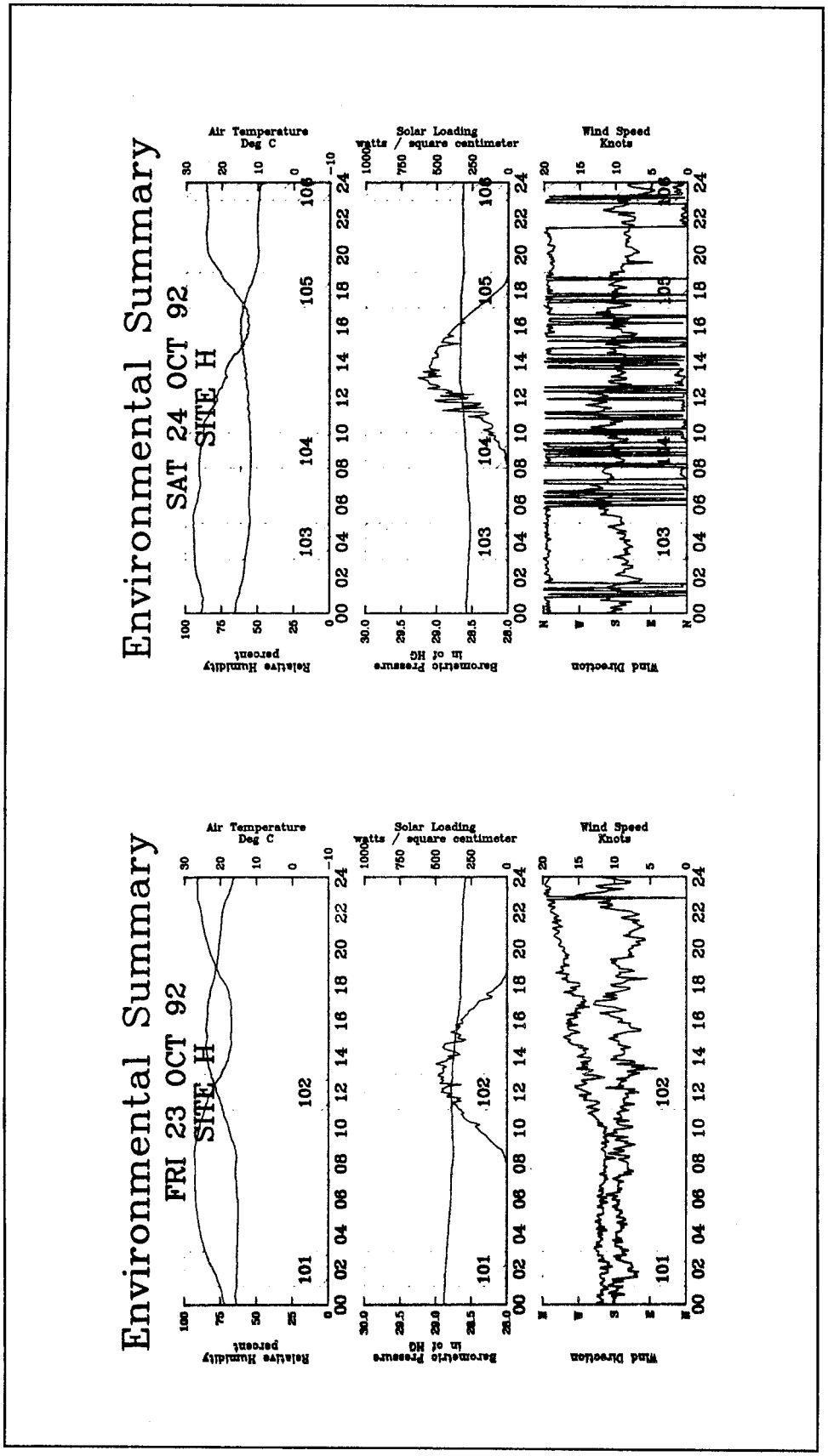

Environmental Summary
WED 14 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
TUE 13 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction

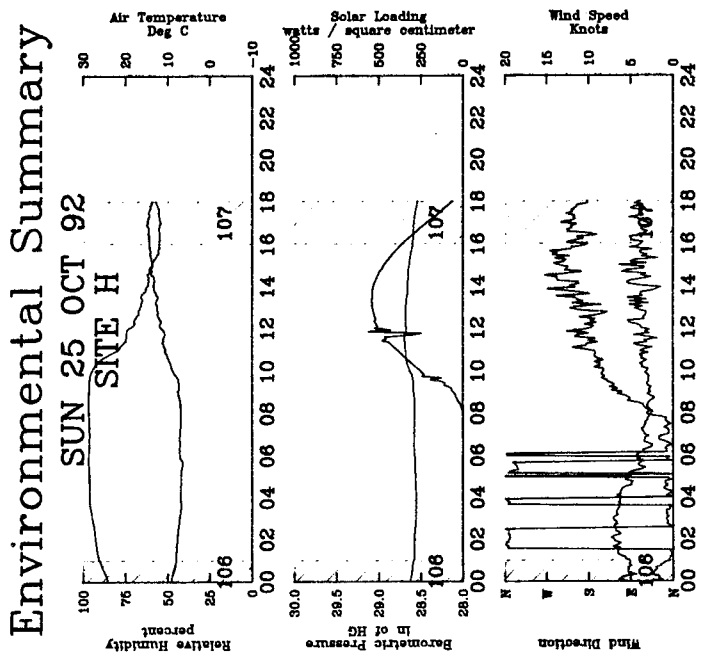

Environmental Summary
FRI 16 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
THUR 15 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
In of HG
Wind Speed
Knots
Wind Direction

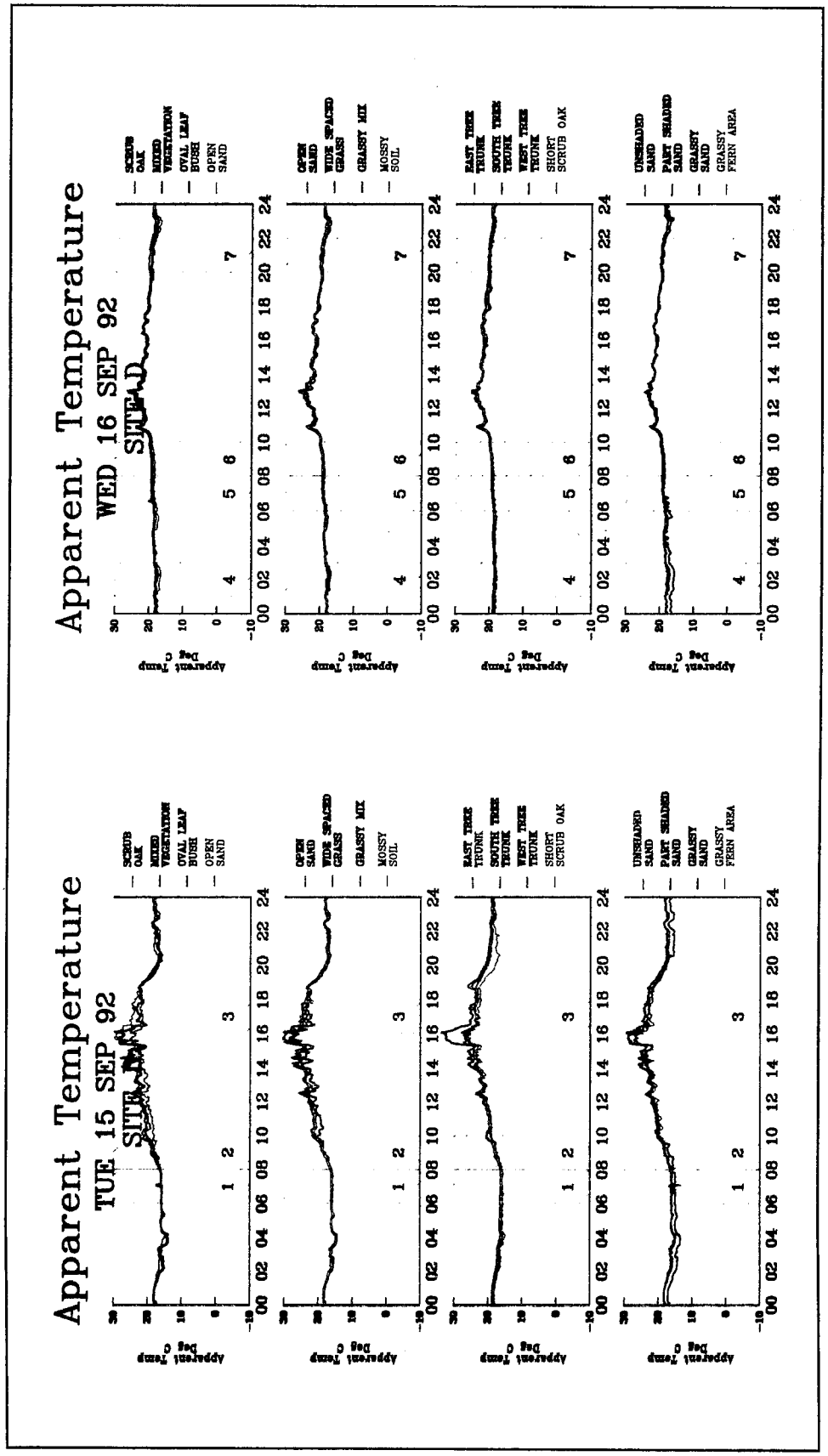

Environmental Summary
SUN 18 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
SAT 17 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction

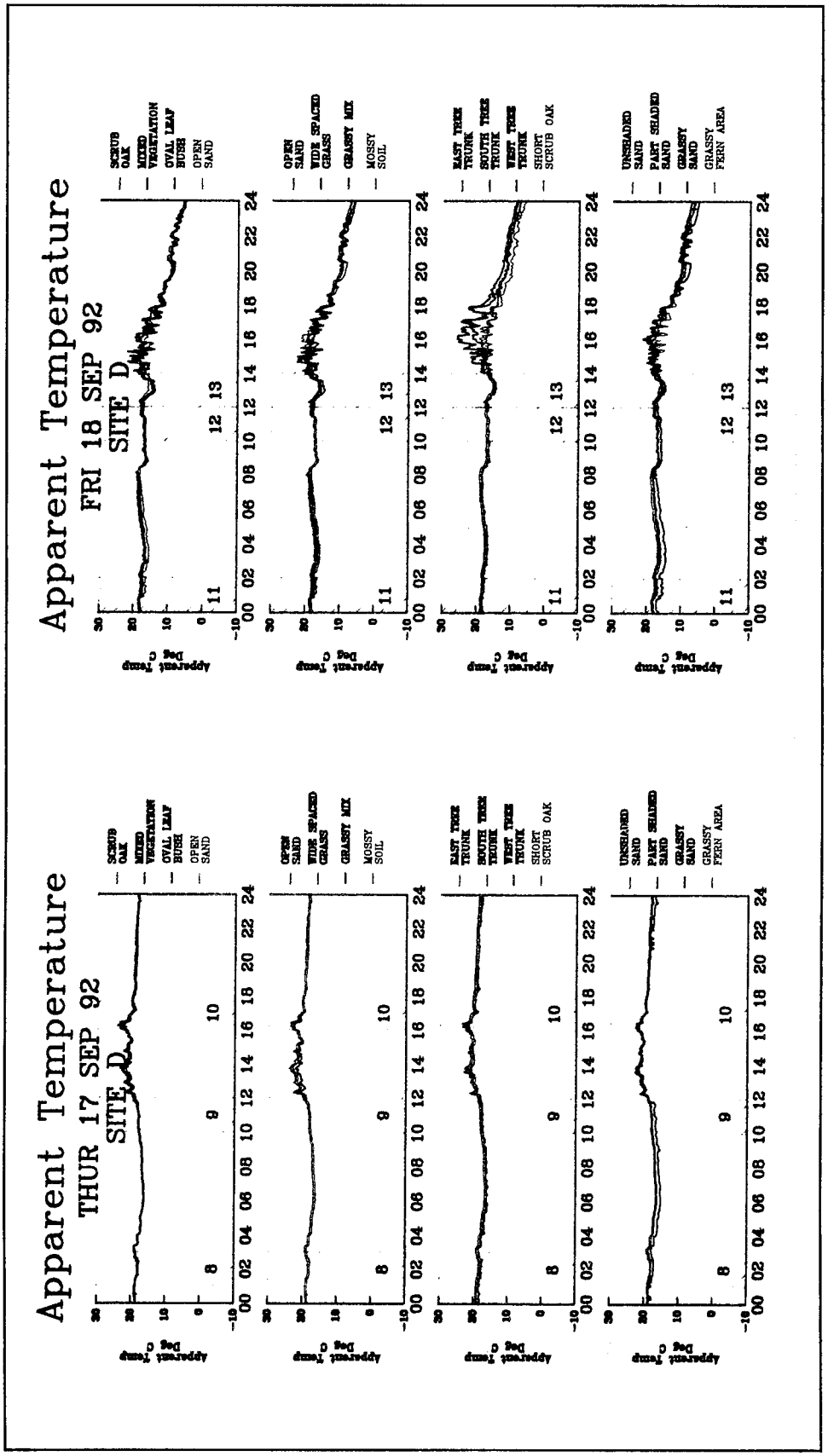

Environmental Summary
TUE 20 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
92
Environmental Summary
MON 19 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
in of HG
Wind Direction
88
89
90
91

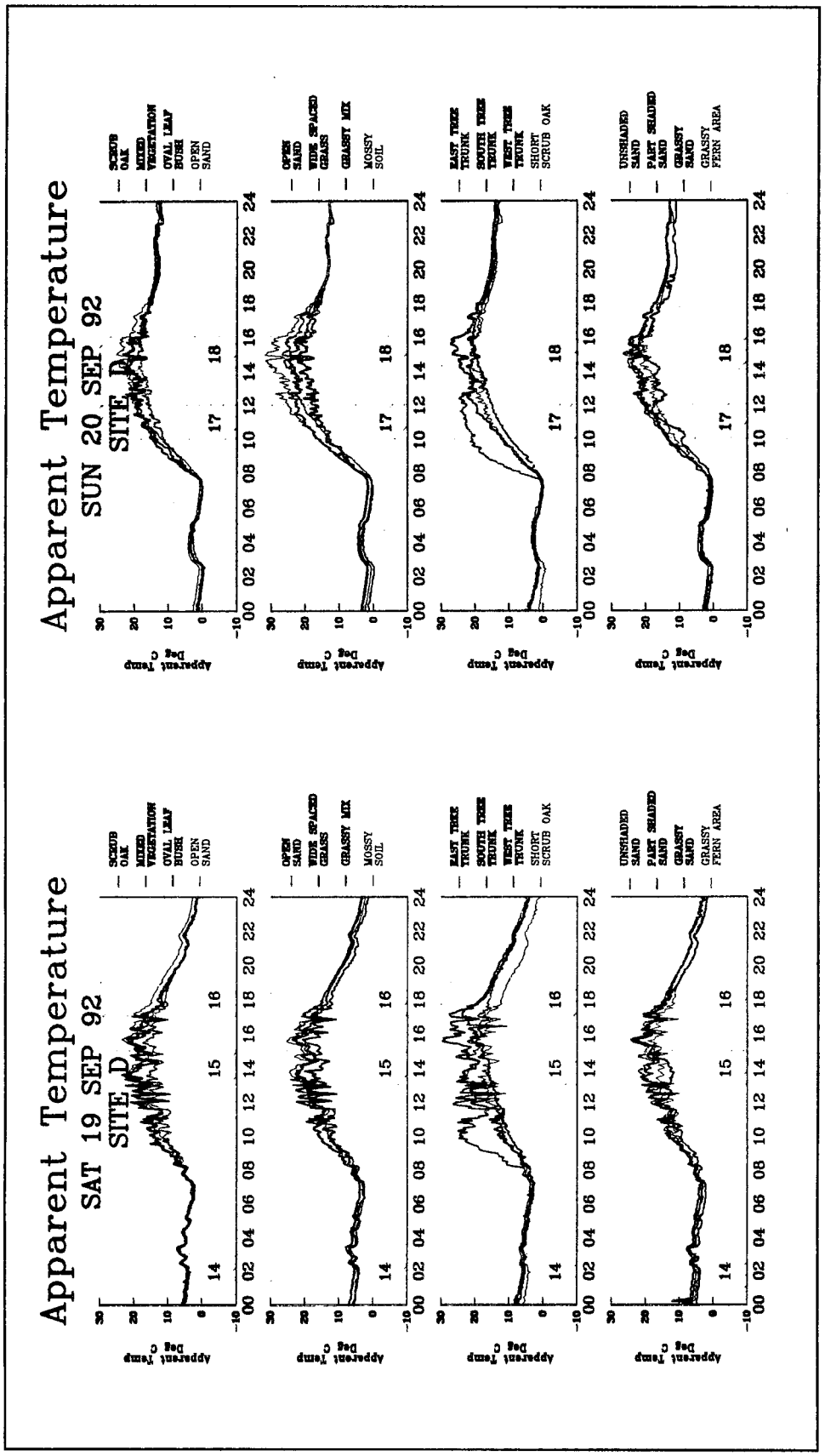

Environmental Summary
THUR 22 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
Environmental Summary
WED 21 OCT 92
SITE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction

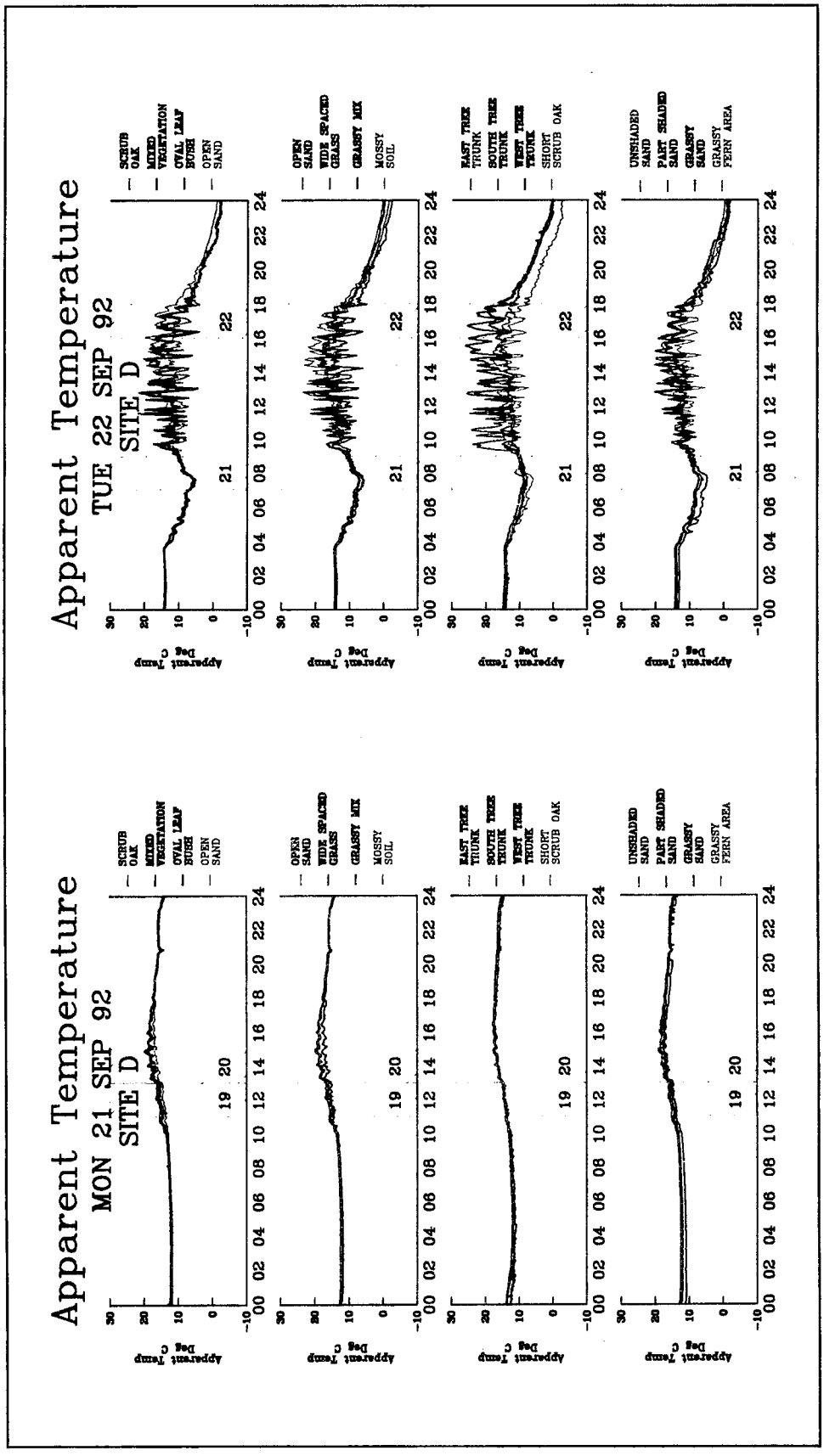

Environmental Summary
SAT 24 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction
103
104
105
106
Environmental Summary
FRI 23 OCT 92
SITE H
Air Temperature
Deg C
Solar Loading
watts / square centimeter
Wind Speed
Knots
Relative Humidity
percent
Barometric Pressure
In of HG
Wind Direction
101
102

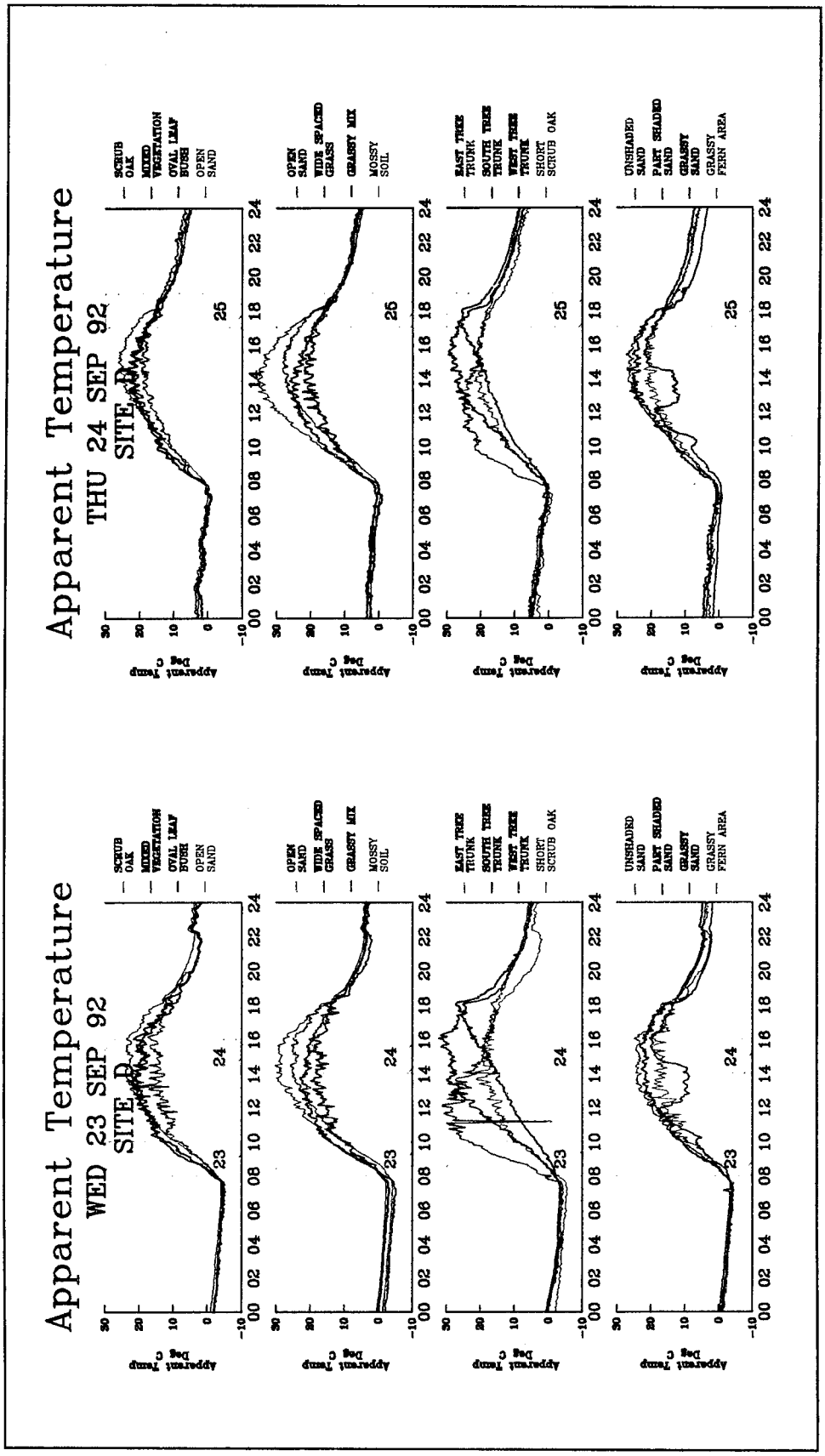

Environmental Summary
SUN 25 OCT 92
SNTE H
Air Temperature
Deg C
Relative Humidity
percent
Solar Loading
watts / square centimeter
Barometric Pressure
in of HG
Wind Speed
Knots
Wind Direction
106
107

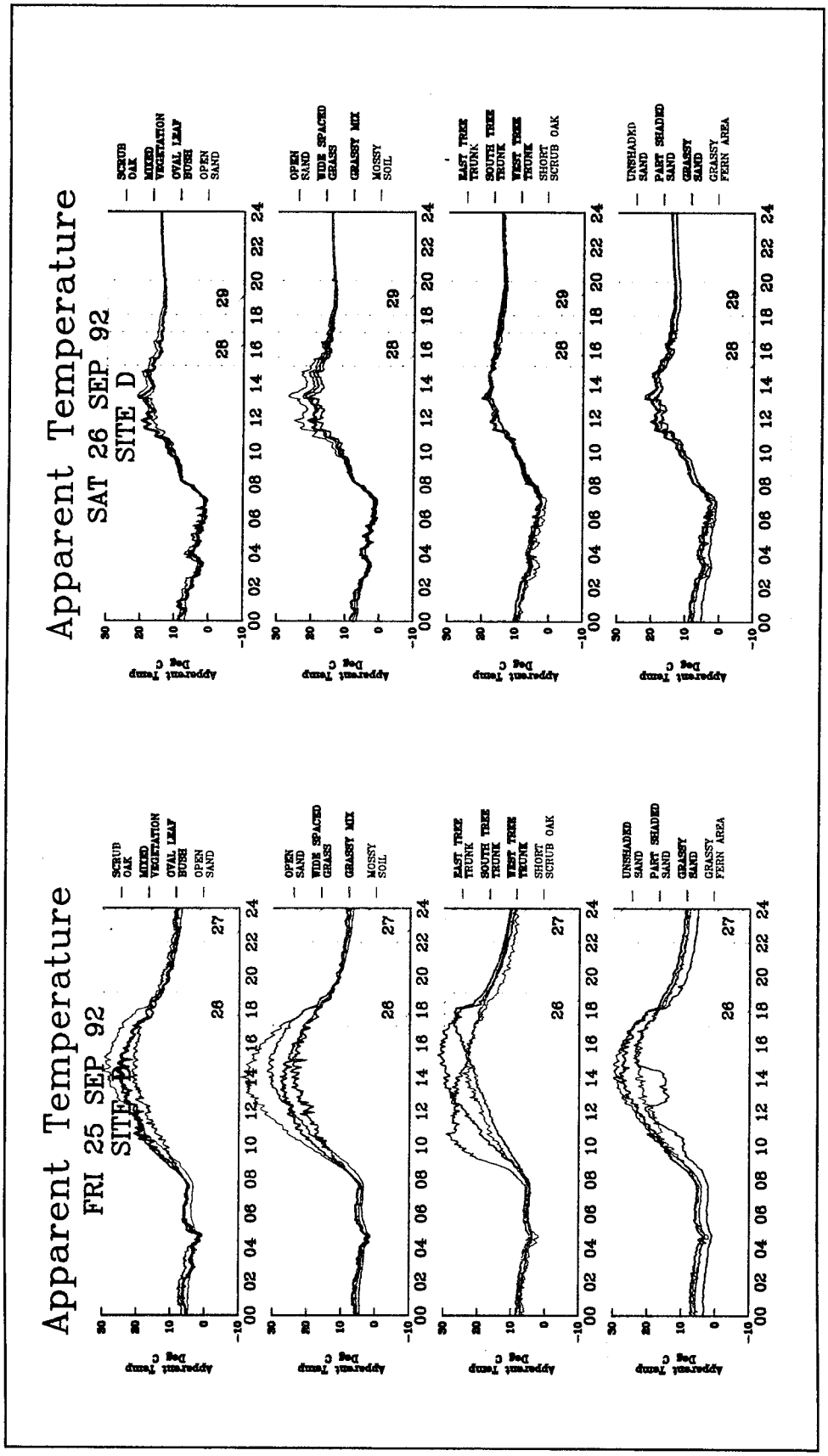

Apparent Temperature
TUE 15 SEP 92
SITE A
Apparent Temperature
WED 16 SEP 92
SITE A
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24
1 2 3 4 5 6 7

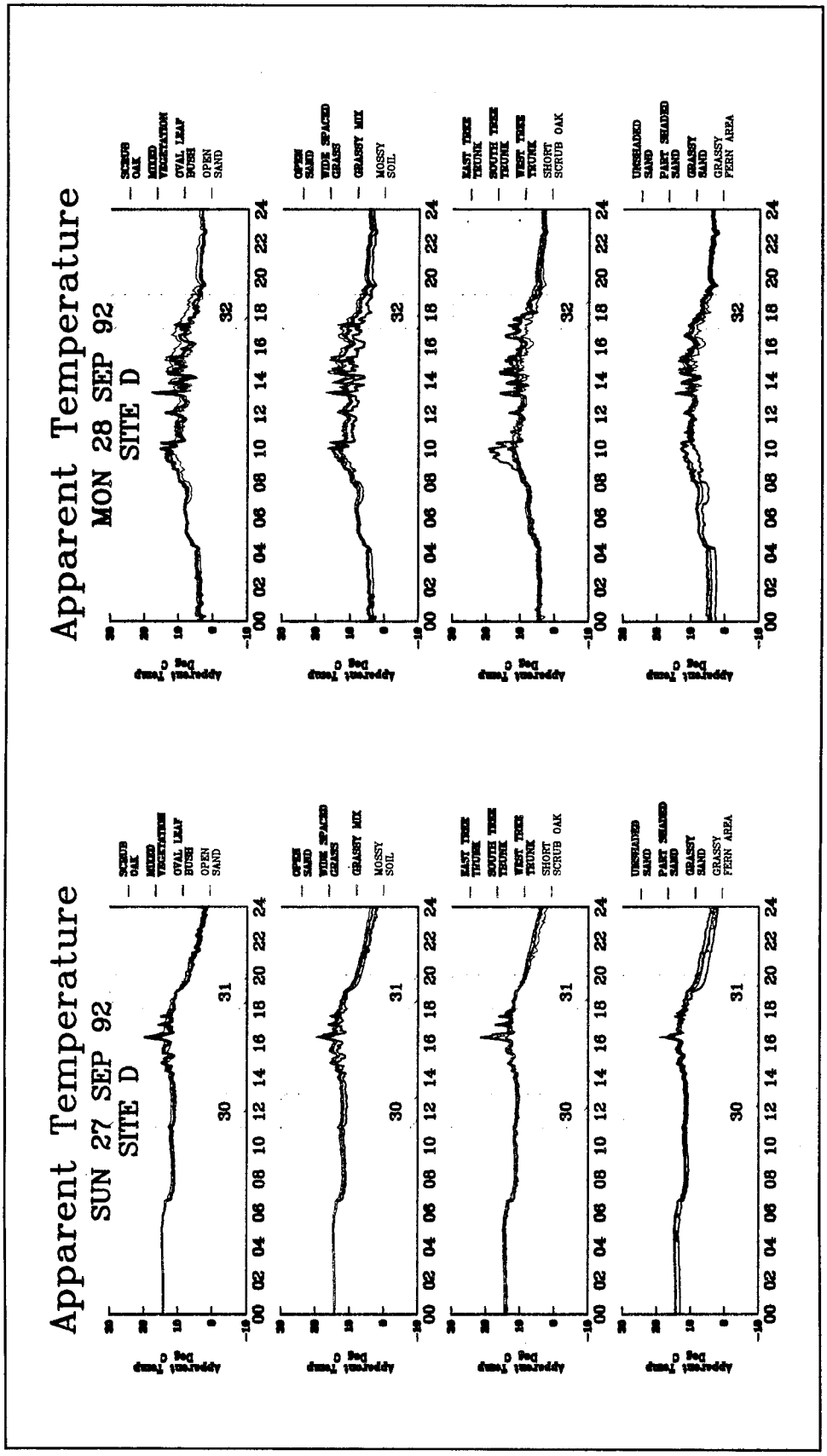

Apparent Temperature
FRI 18 SEP 92
SITE D
Apparent Temperature
THUR 17 SEP 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24

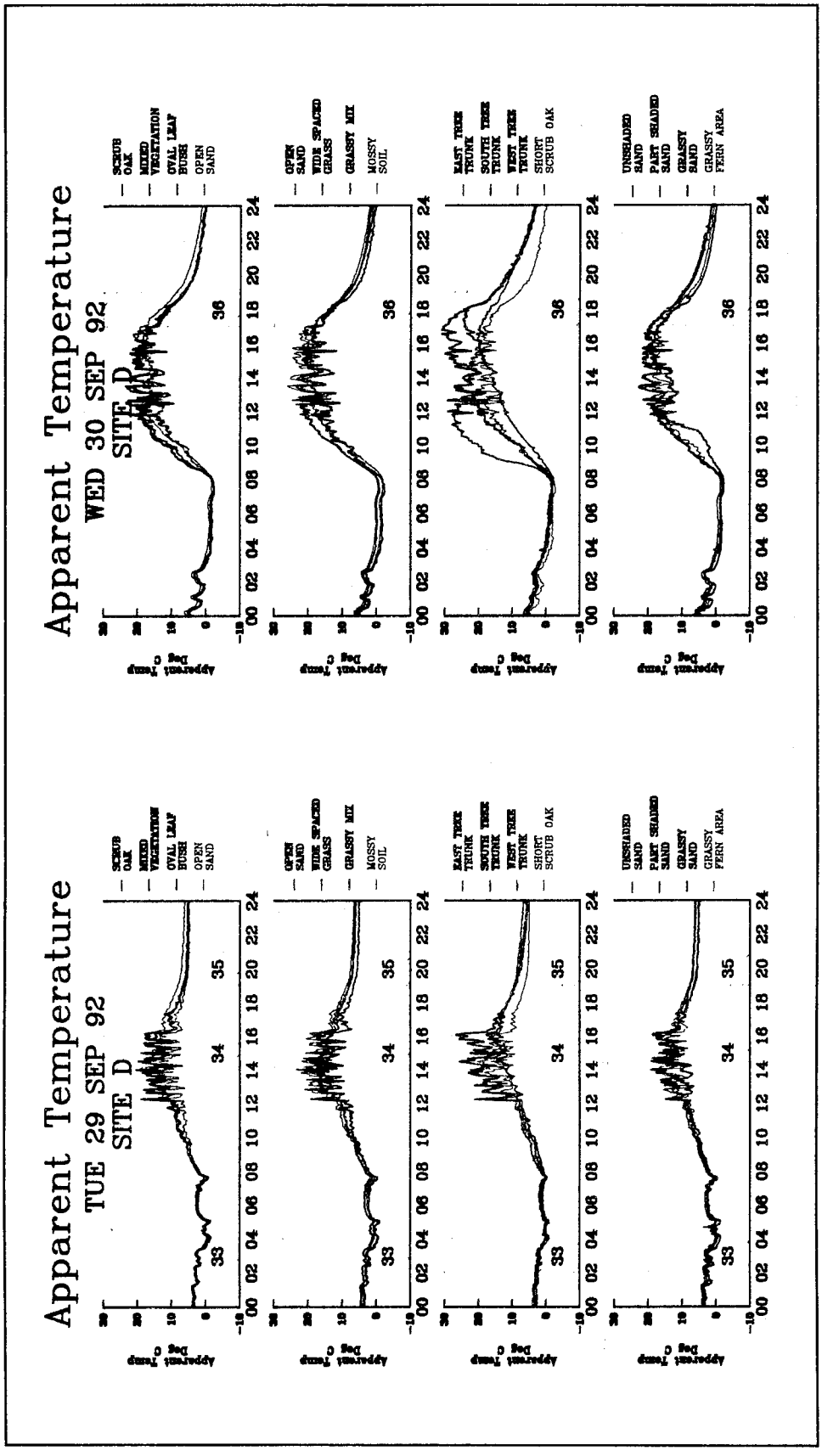

Apparent Temperature
SAT 19 SEP 92
SITE D
Apparent Temperature
SUN 20 SEP 92
SITE D
Deg C
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA

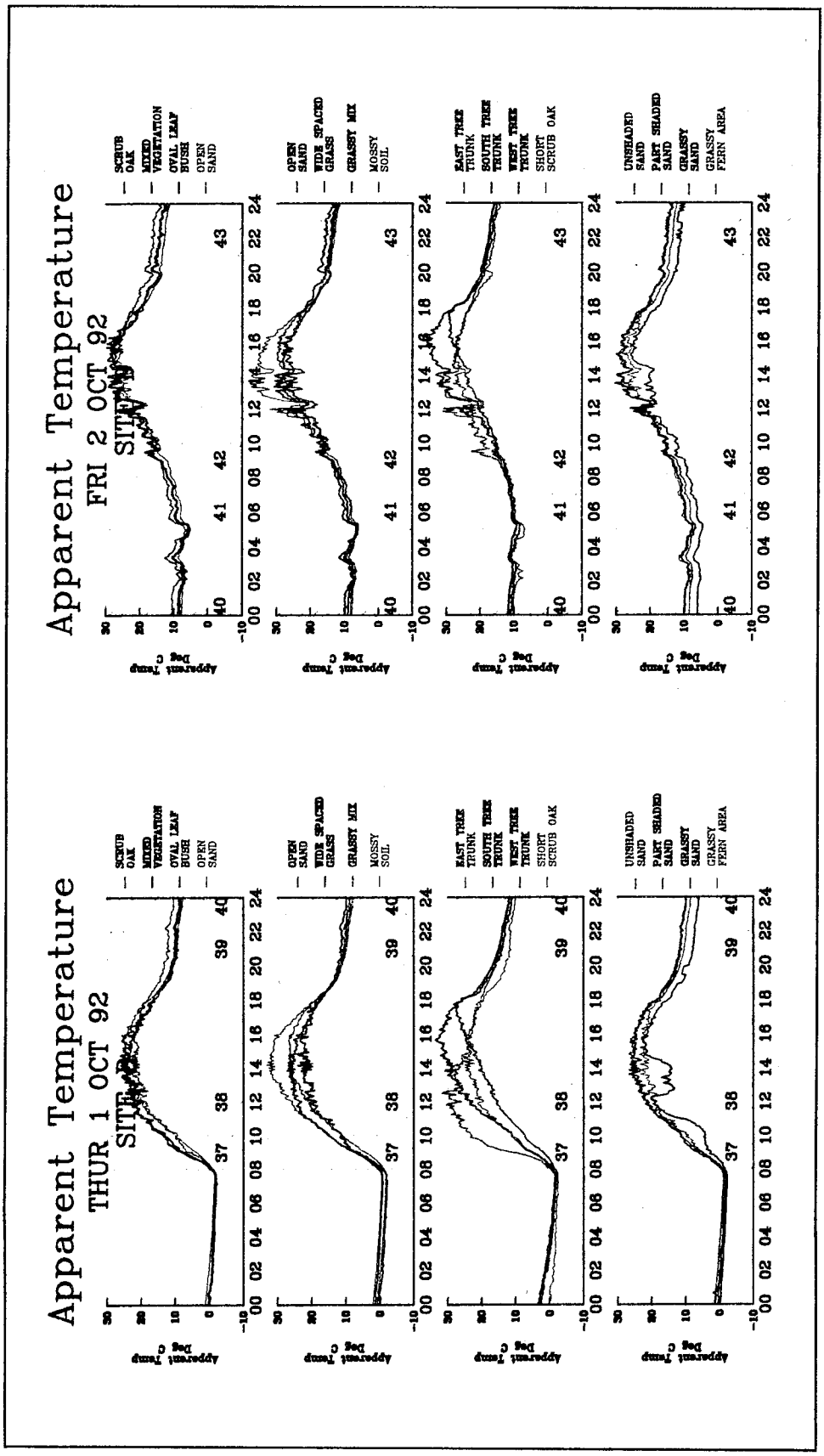

Apparent Temperature
MON 21 SEP 92
SITE D
Apparent Temperature
TUE 22 SEP 92
SITE D
Deg C
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
19
20
21
22

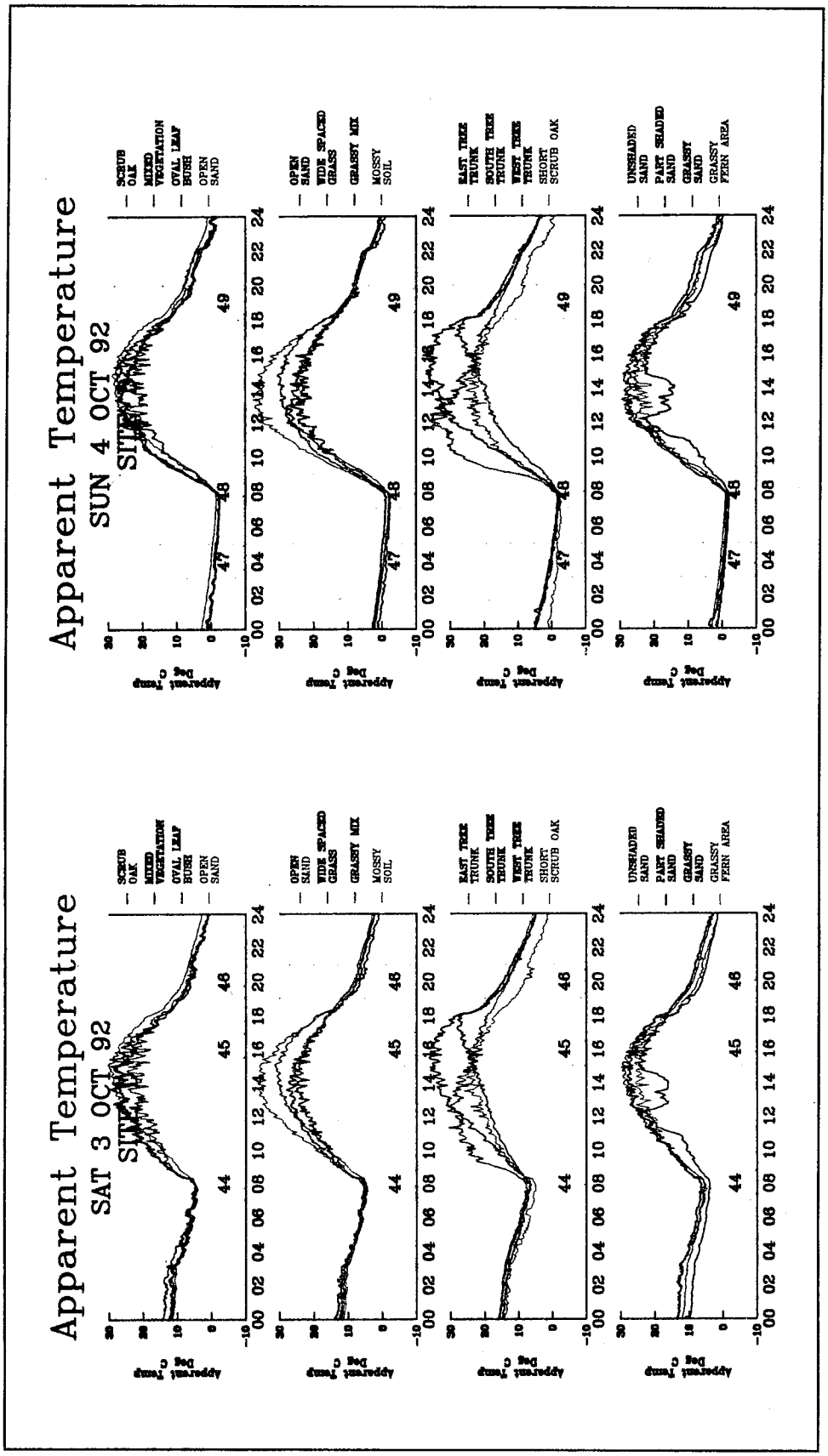

Apparent Temperature
WED 23 SEP 92
SITE B
Apparent Temperature
THU 24 SEP 92
SITE B
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
23
24
25

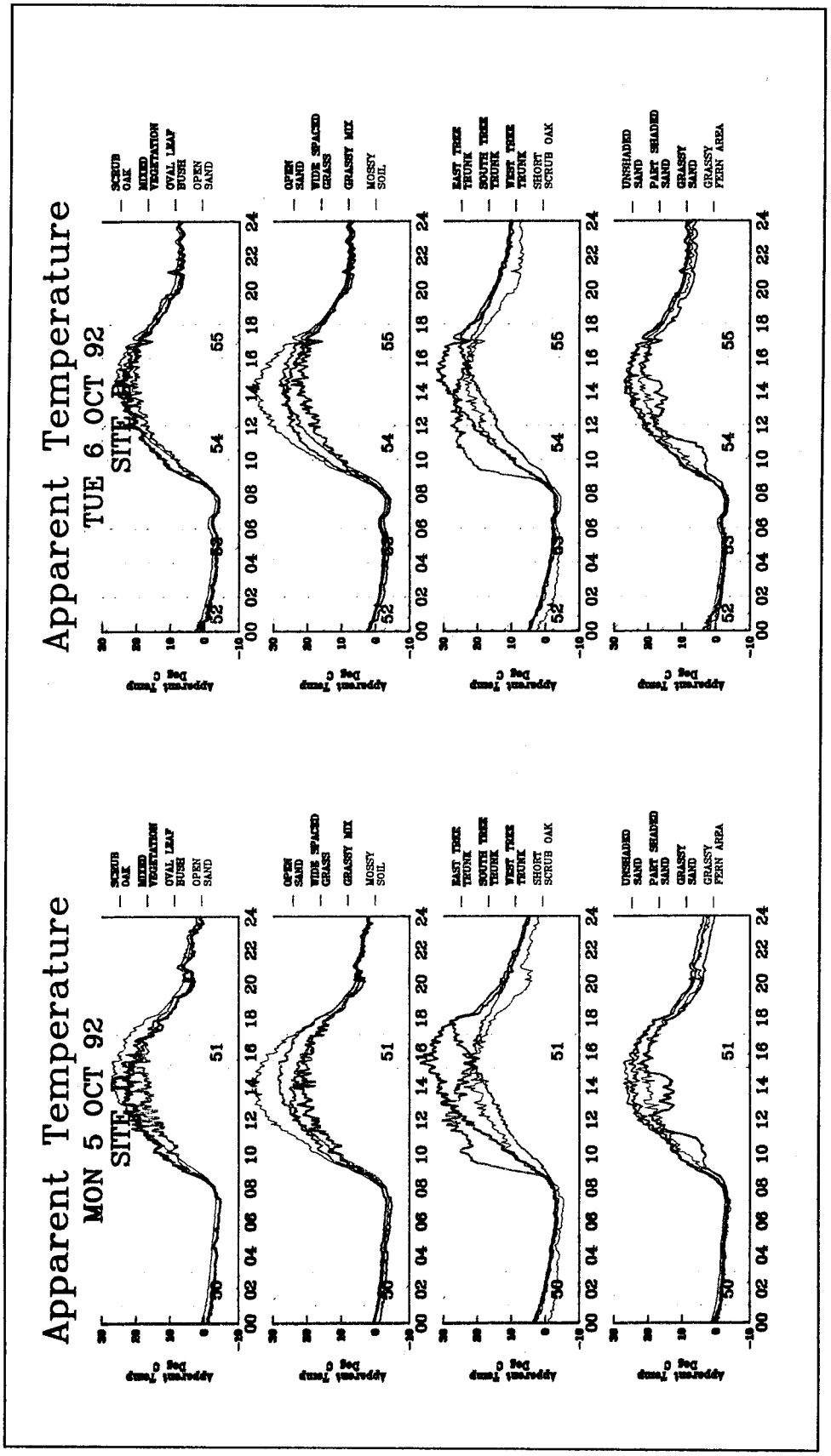

Apparent Temperature
SAT 26 SEP 92
SITE D
Apparent Temperature
FRI 25 SEP 92
SITE D
Deg C
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA

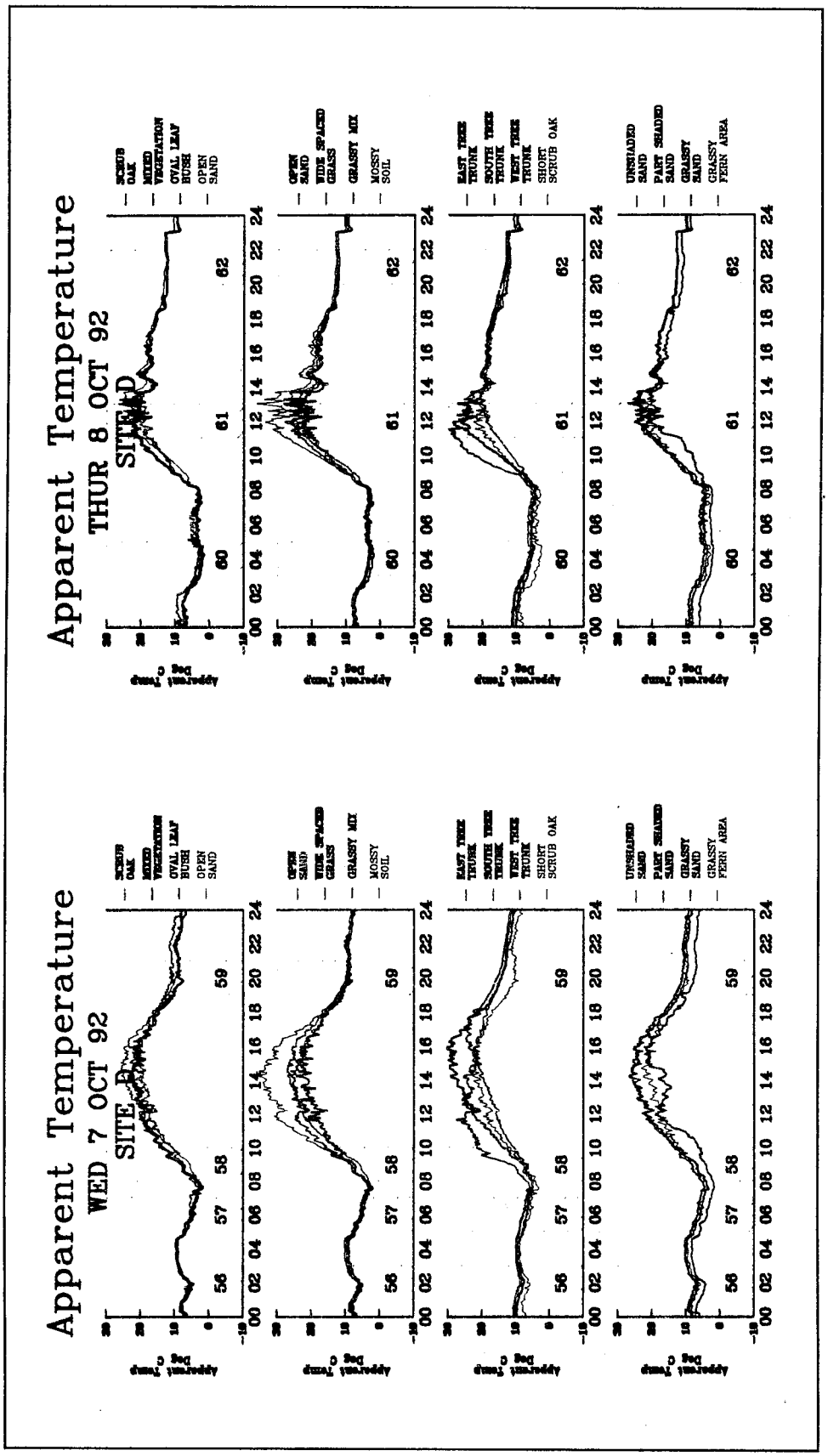

Apparent Temperature
SUN 27 SEP 92
SITE D
Apparent Temperature
MON 28 SEP 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24
30
31
32

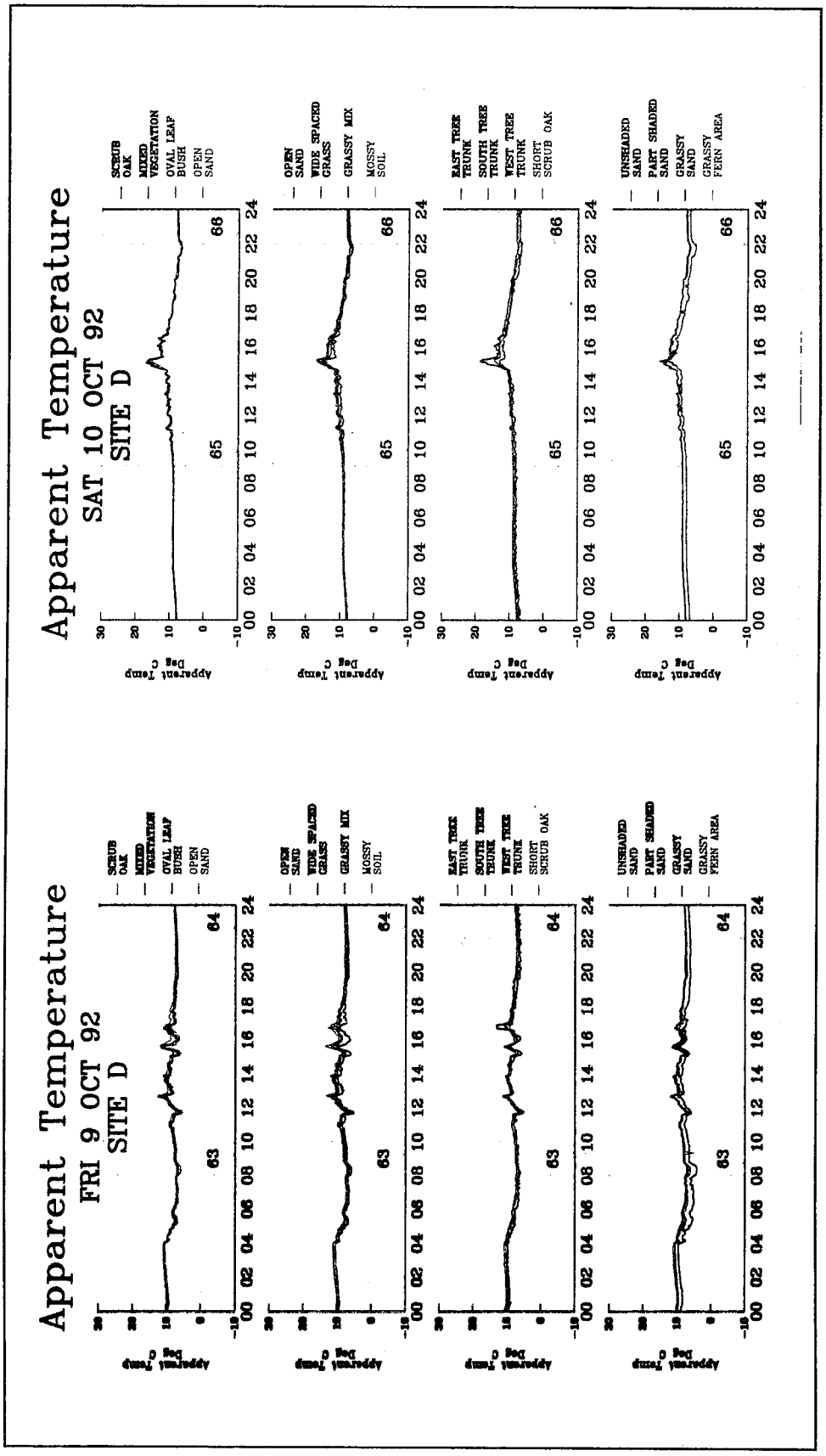

Apparent Temperature
TUE 29 SEP 92
SITE D
Apparent Temperature
WED 30 SEP 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
33
34
35
36

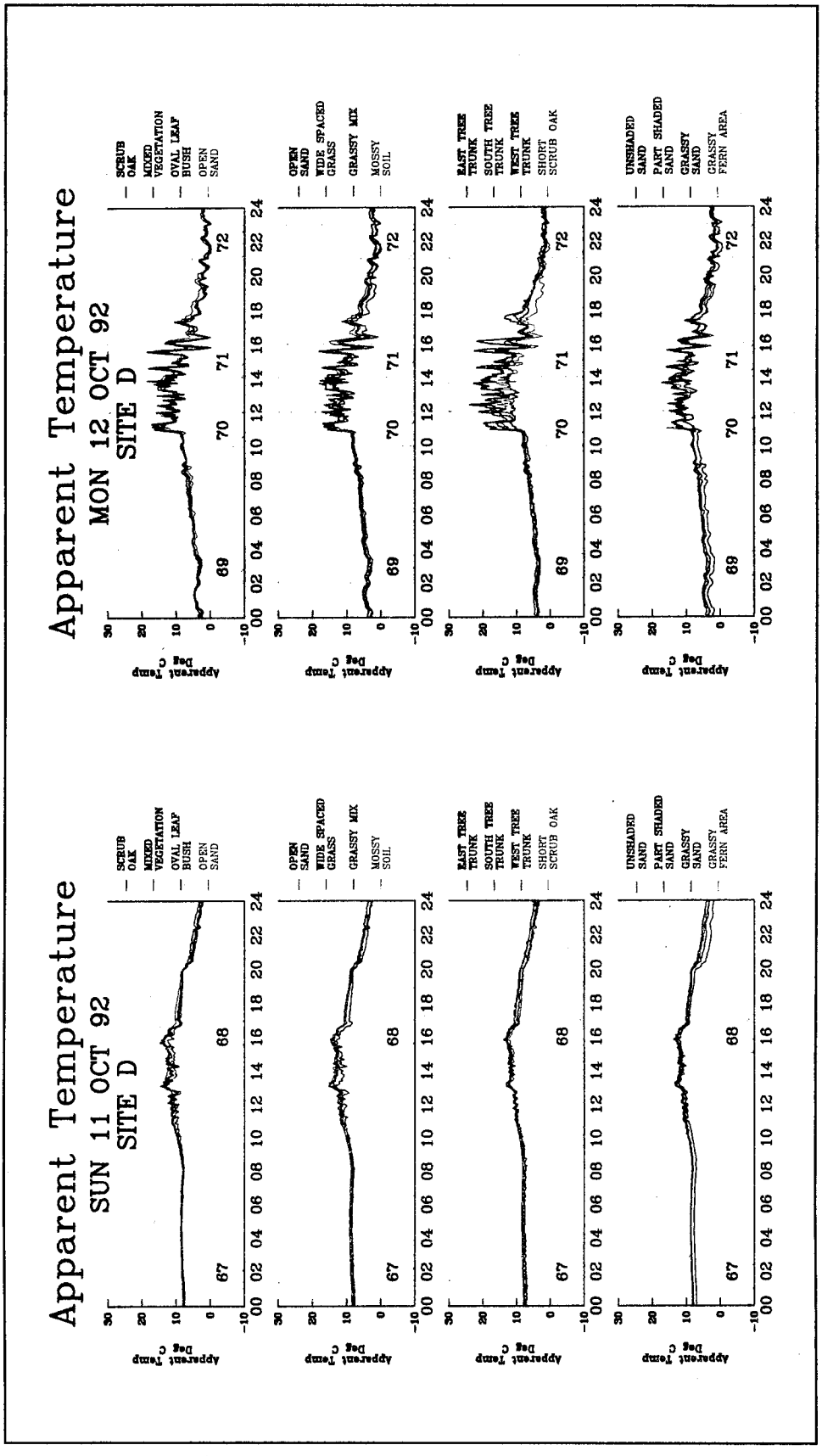

Apparent Temperature
THUR 1 OCT 92
SITE
Apparent Temperature
FRI 2 OCT 92
SITE
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24
37 38 39 40 41 42 43

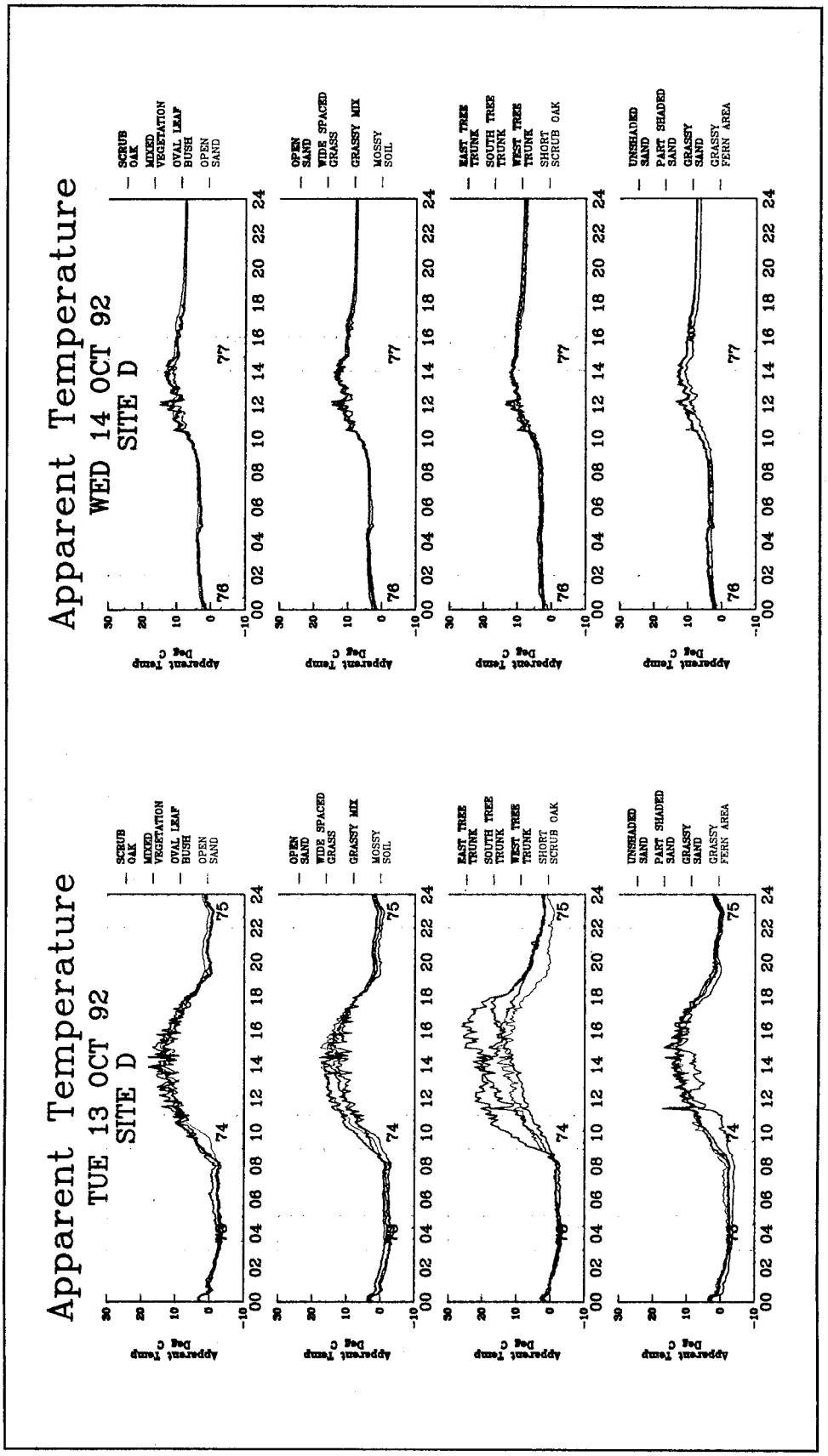

Apparent Temperature
SUN 4 OCT 92
SITE C
SAT 3 OCT 92
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
44
45
46
47
48
49

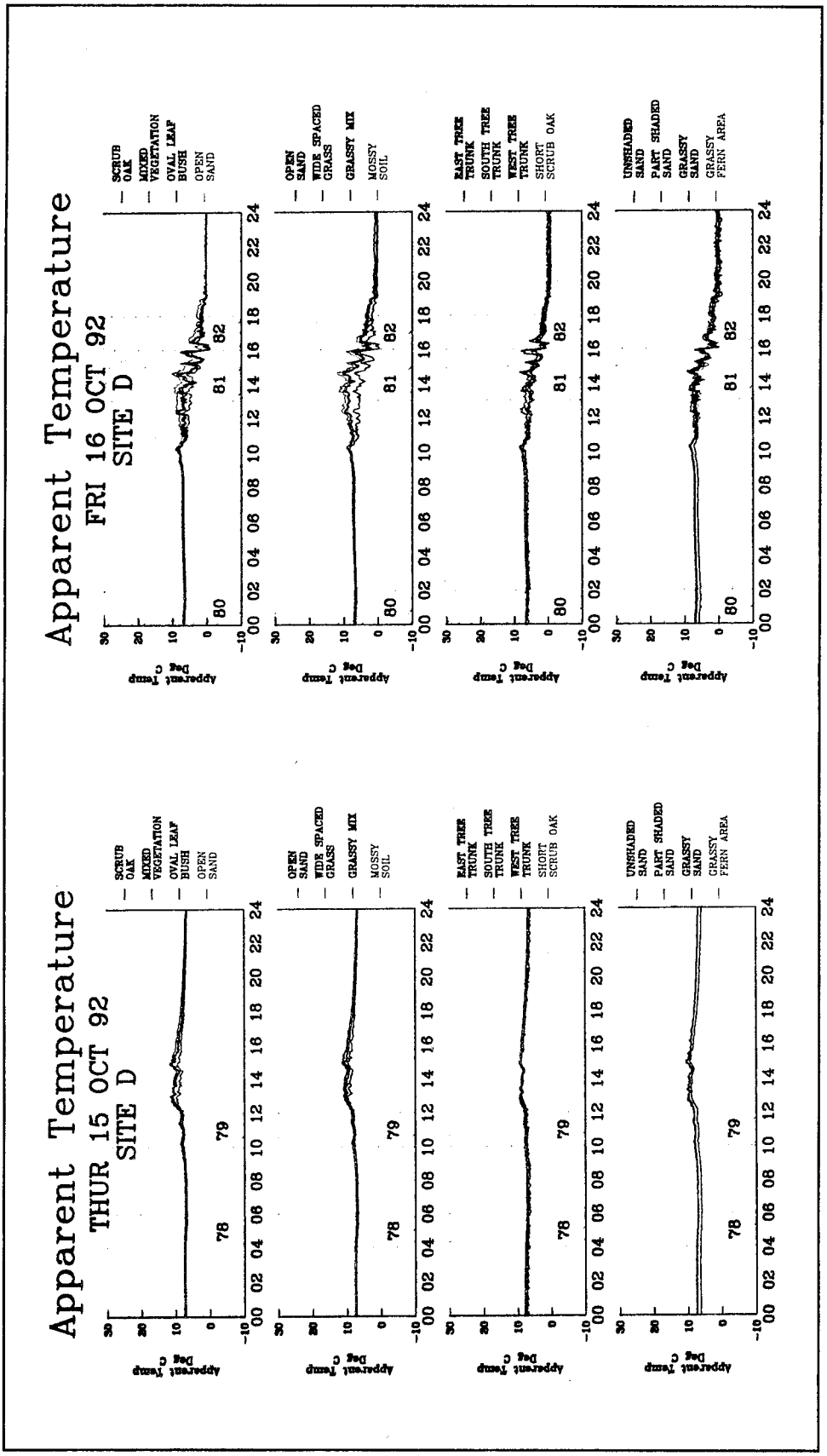

Apparent Temperature
MON 5 OCT 92
SITE D
Apparent Temperature
TUE 6 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24

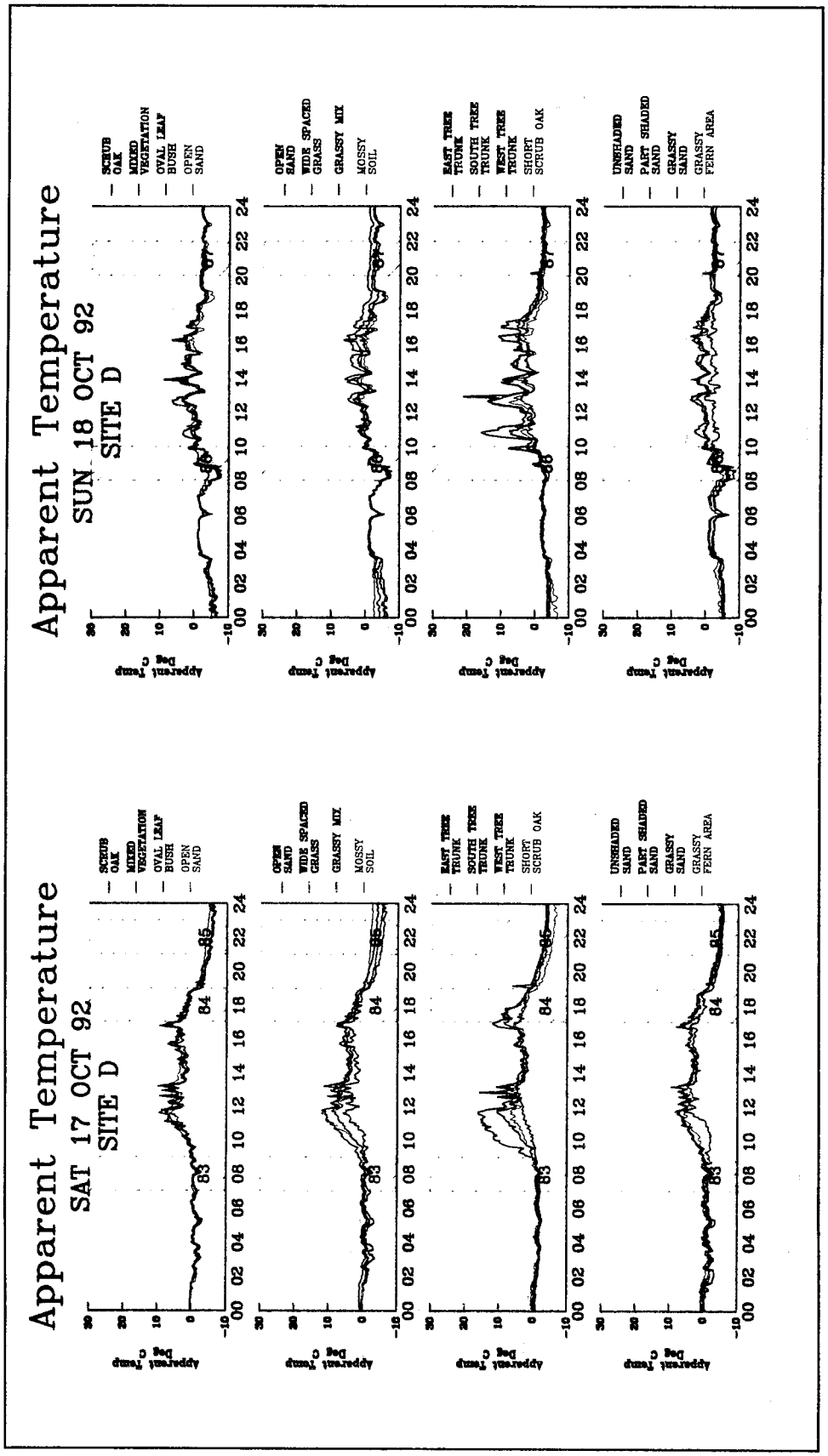

Apparent Temperature
THUR 8 OCT 92
SITE D
Apparent Temperature
WED 7 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24
56 57 58 59 60 61 62

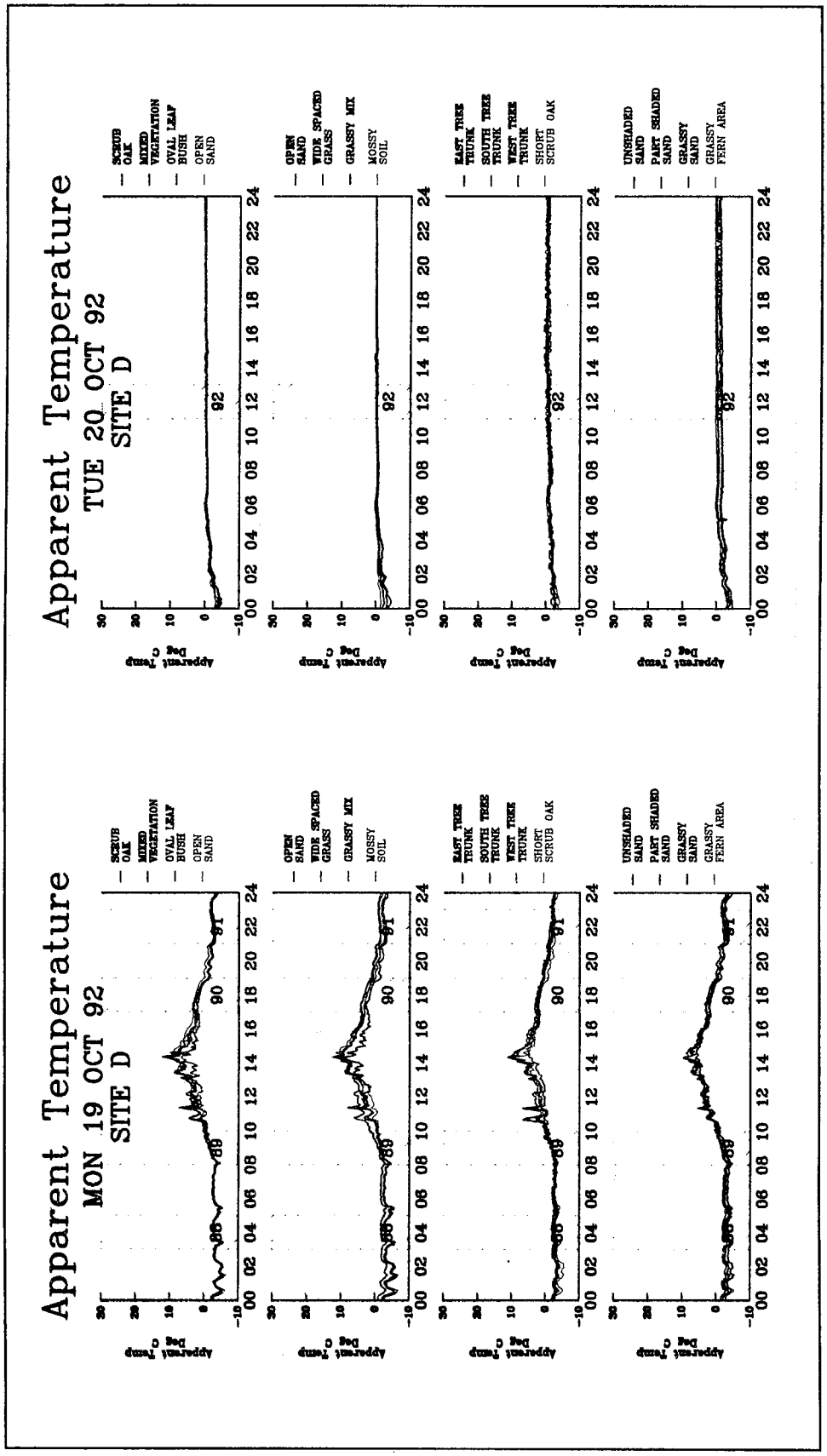

Apparent Temperature
FRI 9 OCT 92
SITE D
Apparent Temperature
SAT 10 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
63
64
65
66

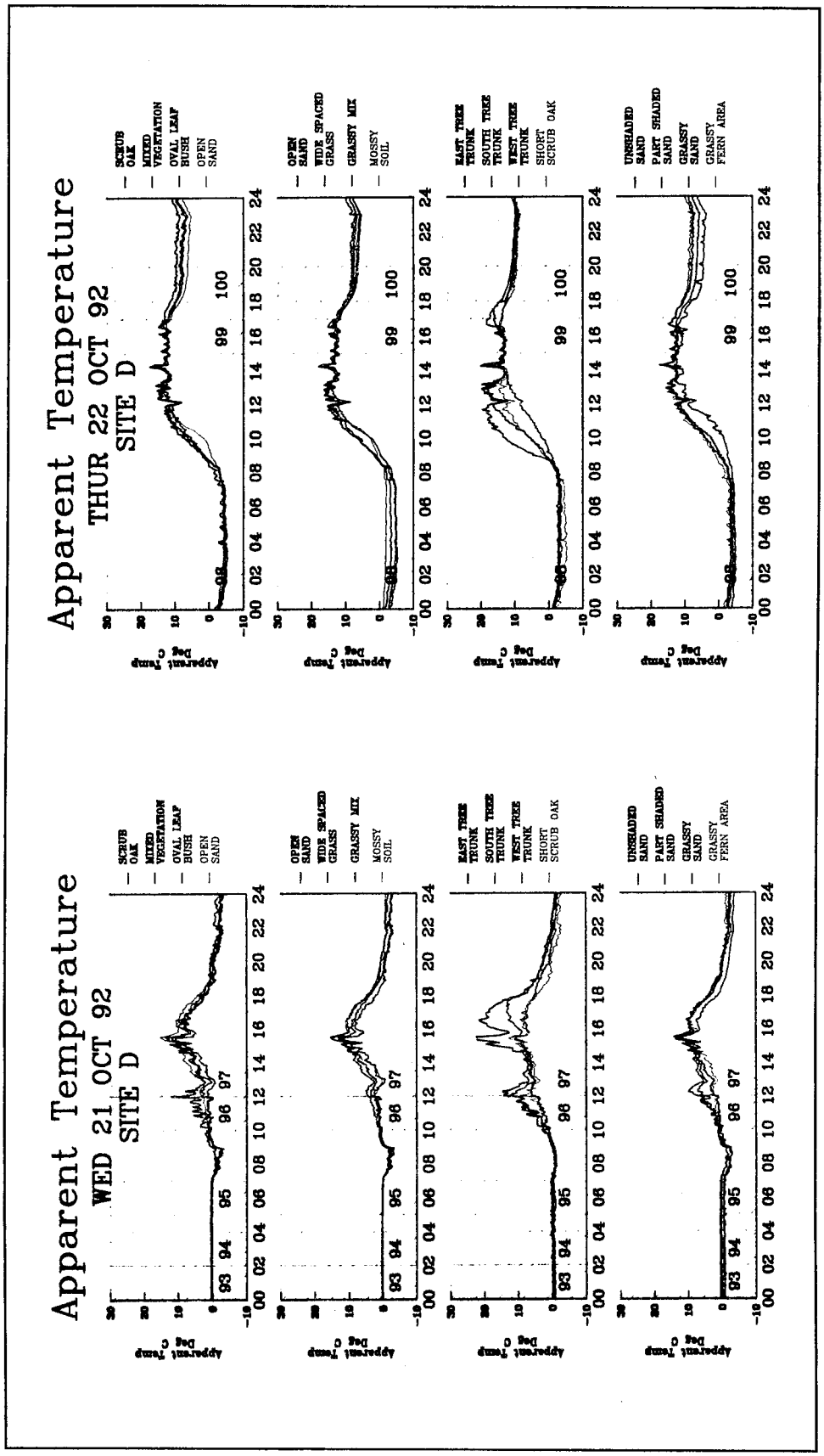

Apparent Temperature
SUN 11 OCT 92
SITE D
Apparent Temperature
MON 12 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Deg C
67
68
69
70
71
72

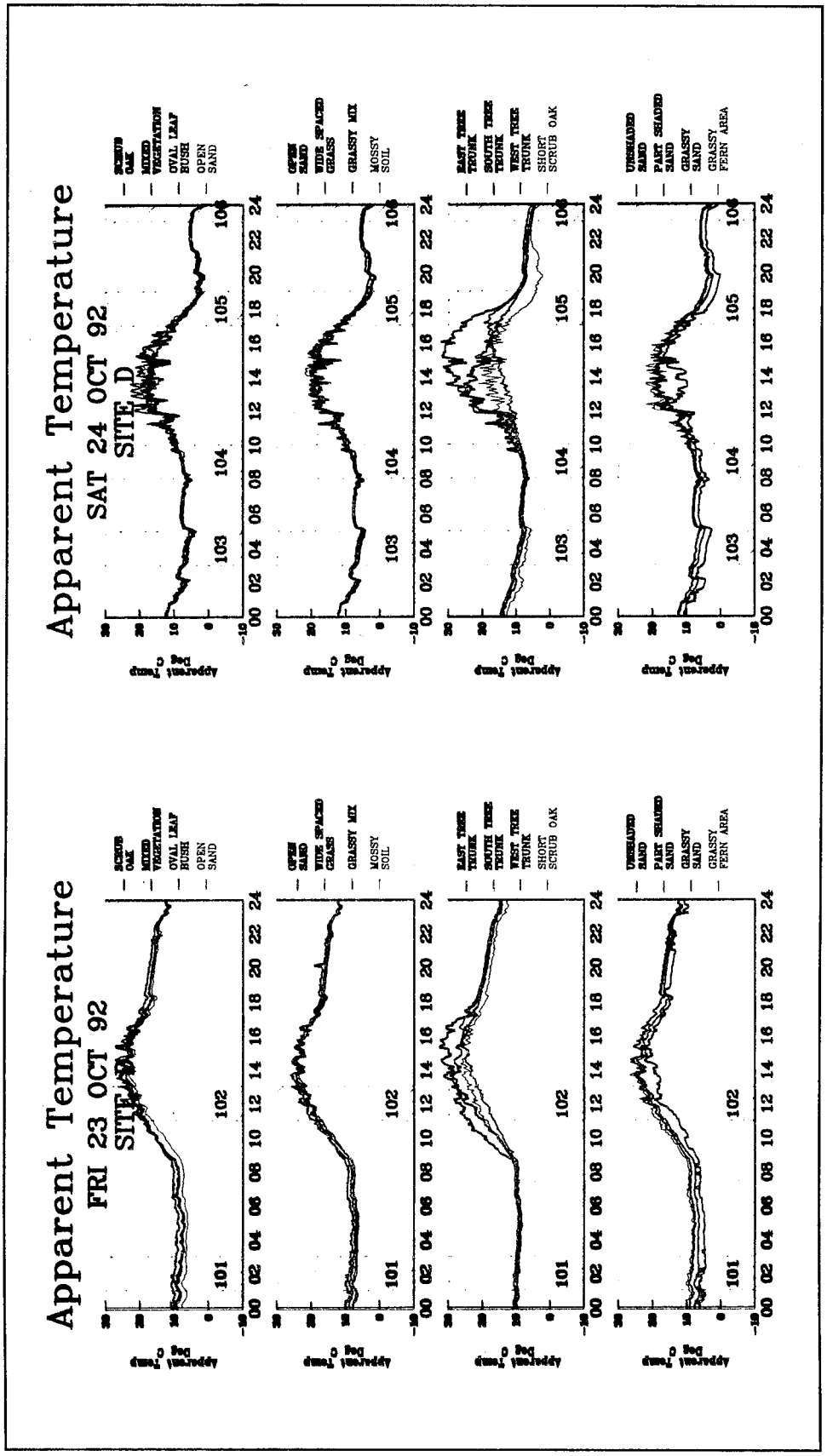

Apparent Temperature
TUE 13 OCT 92
SITE D
Apparent Temperature
WED 14 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
74
75
76
77
00 02 04 06 08 10 12 14 16 18 20 22 24
-10 0 10 20 30

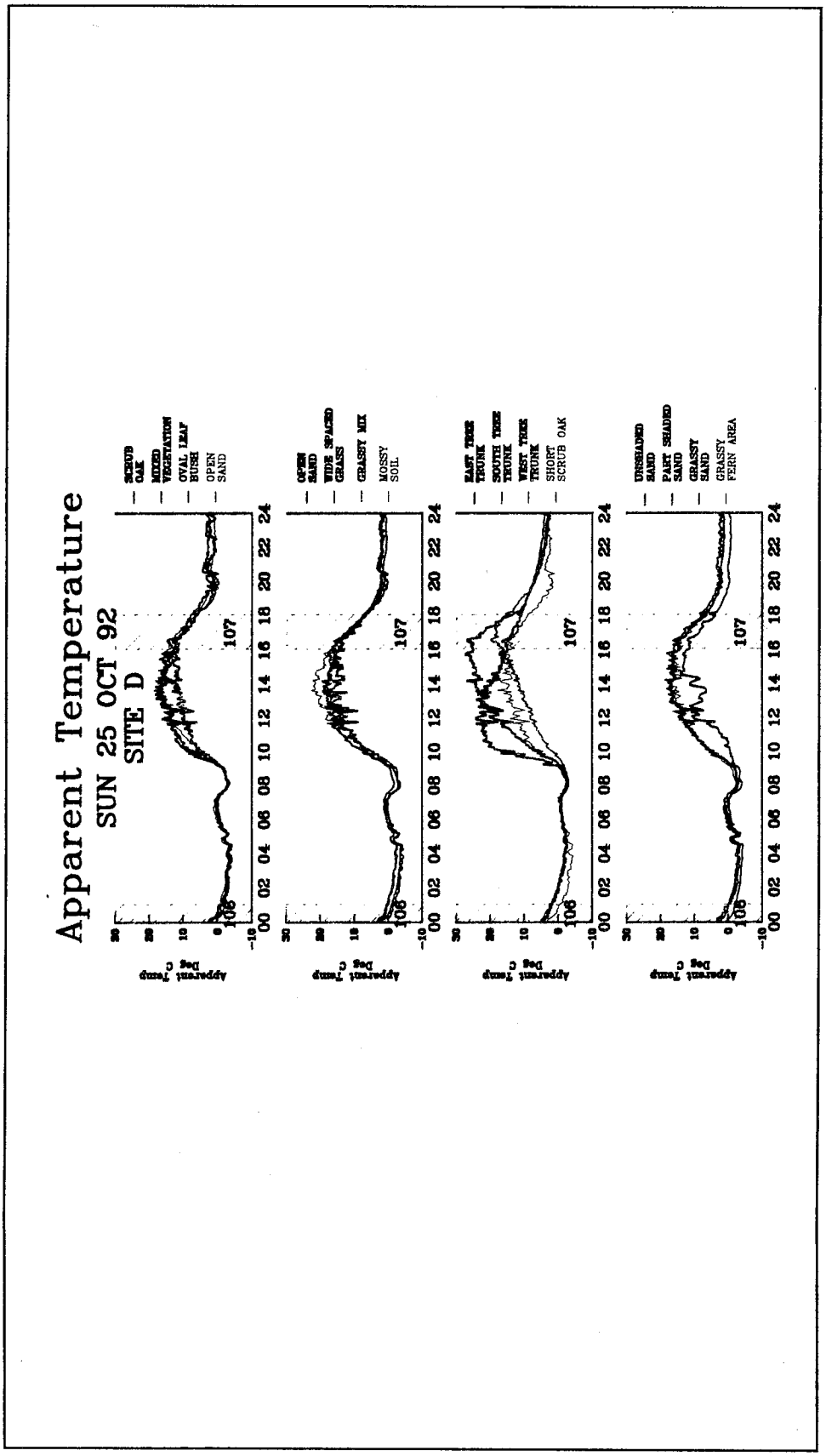

Apparent Temperature
THUR 15 OCT 92
SITE D
Apparent Temperature
FRI 16 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
78
79
80
81
82

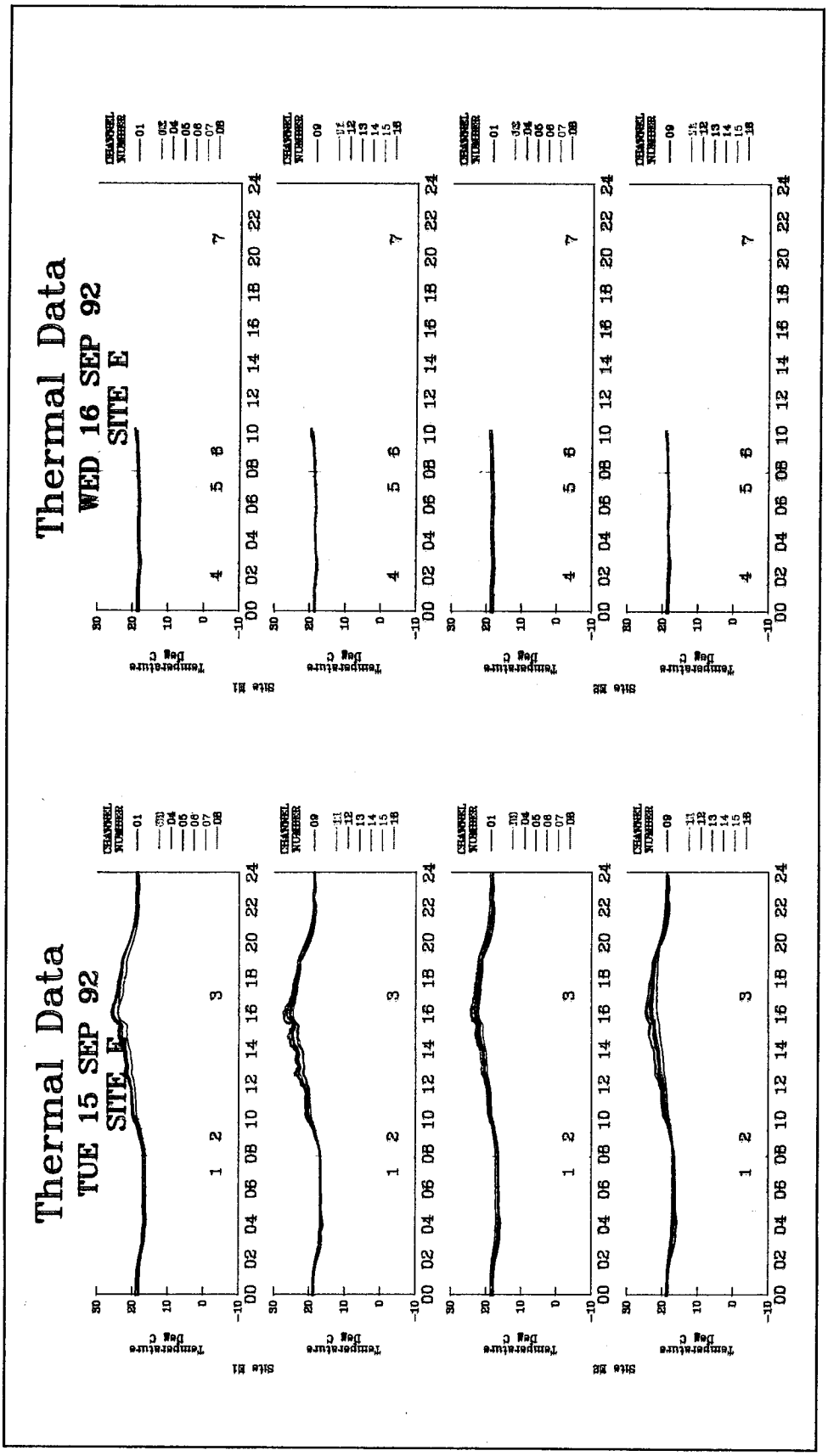

Apparent Temperature
SAT 17 OCT 92
SITE D
Apparent Temperature
SUN 18 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHOPP SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24

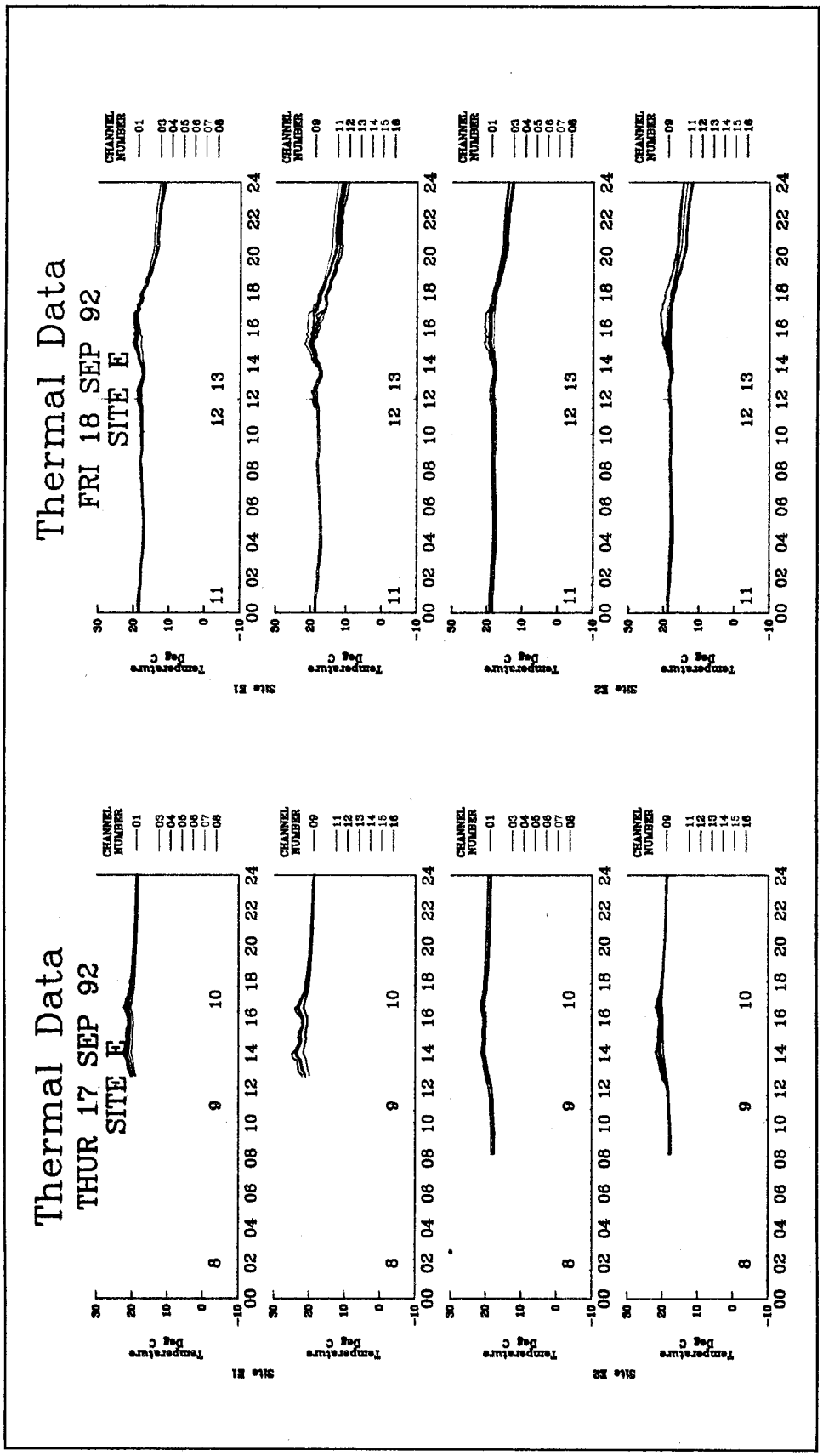

Apparent Temperature
MON 19 OCT 92
SITE D
Apparent Temperature
TUE 20 OCT 92
SITE D
Deg C
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA

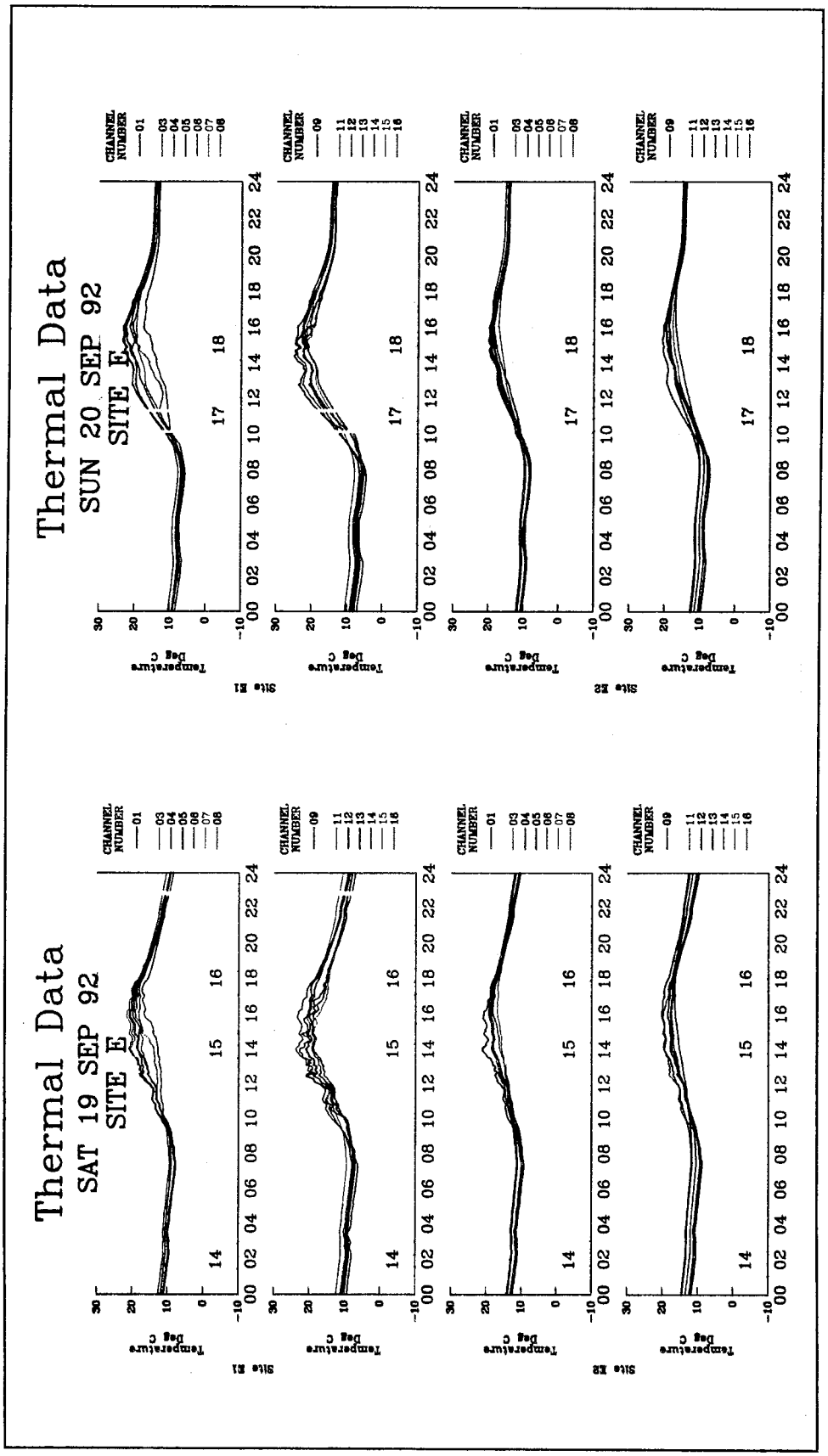

Apparent Temperature
WED 21 OCT 92
SITE D
Apparent Temperature
THUR 22 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C

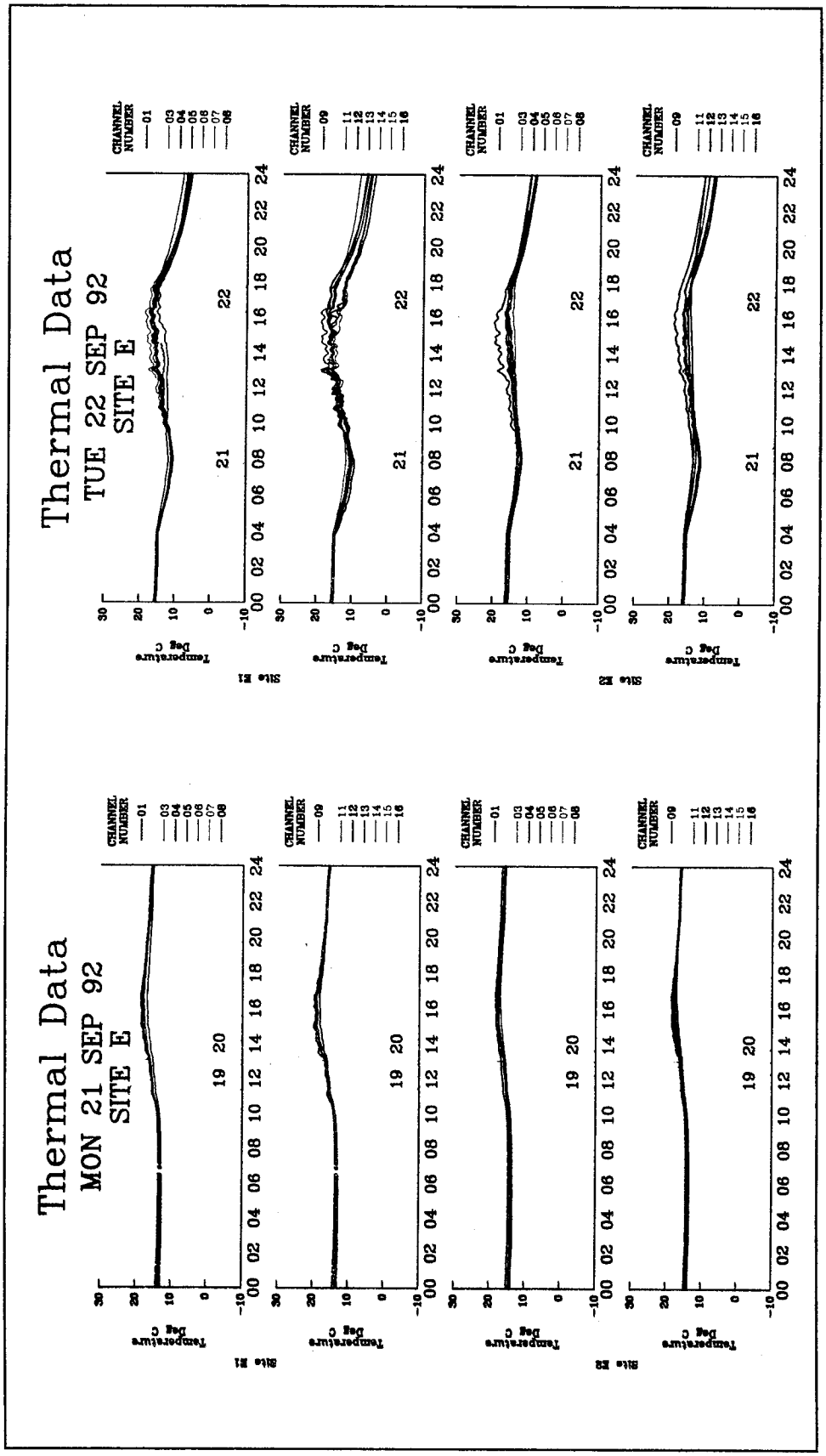

Apparent Temperature
FRI 23 OCT 92
SITE D
Apparent Temperature
SAT 24 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
101
102
103
104
105
106
00 02 04 06 08 10 12 14 16 18 20 22 24

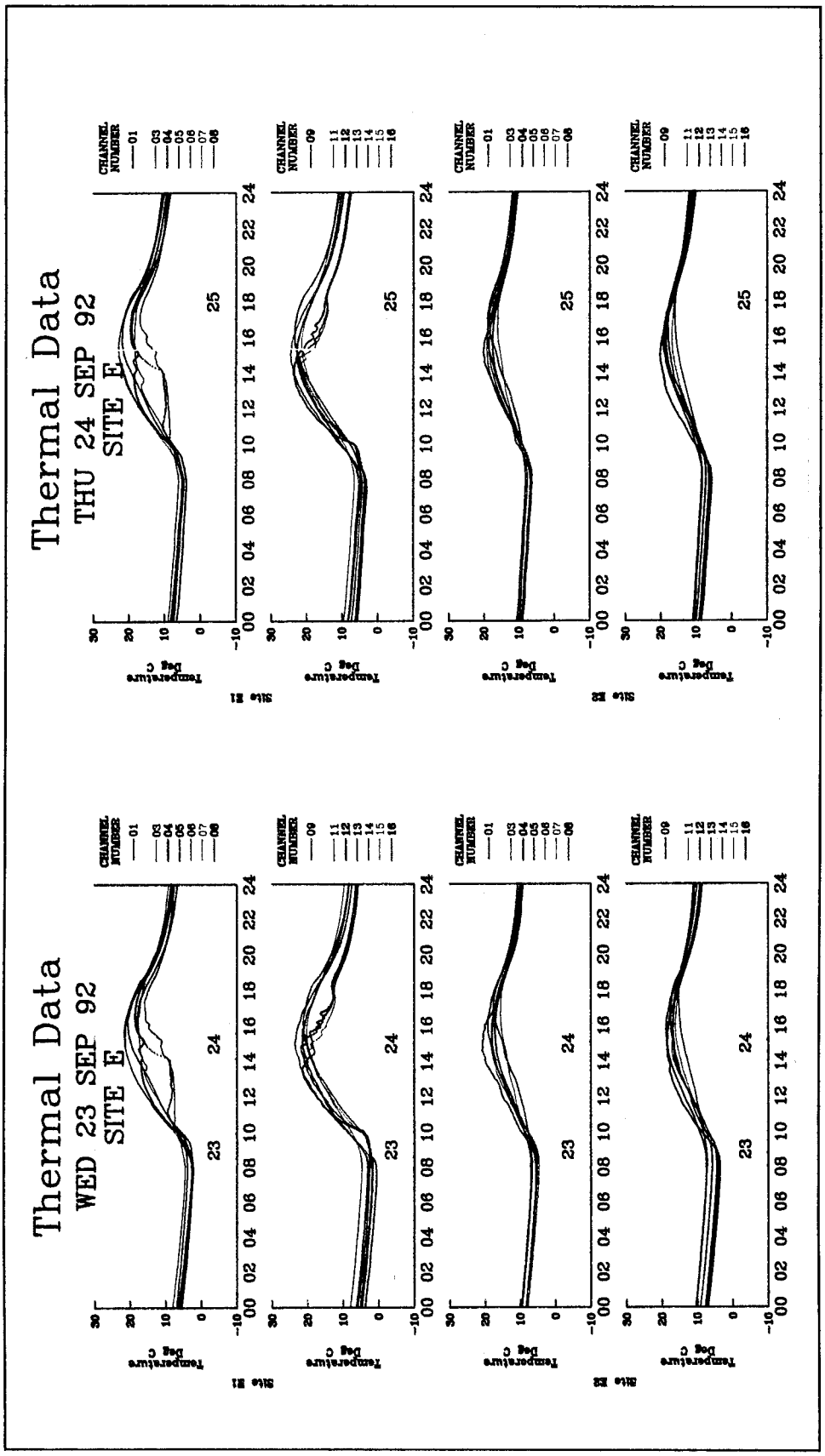

Apparent Temperature
SUN 25 OCT 92
SITE D
SCRUB OAK
MIXED VEGETATION
OVAL LEAF BUSH
OPEN SAND
OPEN SAND
WIDE SPACED GRASS
GRASSY MIX
MOSSY SOIL
EAST TREE TRUNK
SOUTH TREE TRUNK
WEST TREE TRUNK
SHORT SCRUB OAK
UNSHADED SAND
PART SHADED SAND
GRASSY SAND
GRASSY FERN AREA
Apparent Temp Deg C
00 02 04 06 08 10 12 14 16 18 20 22 24
106
107

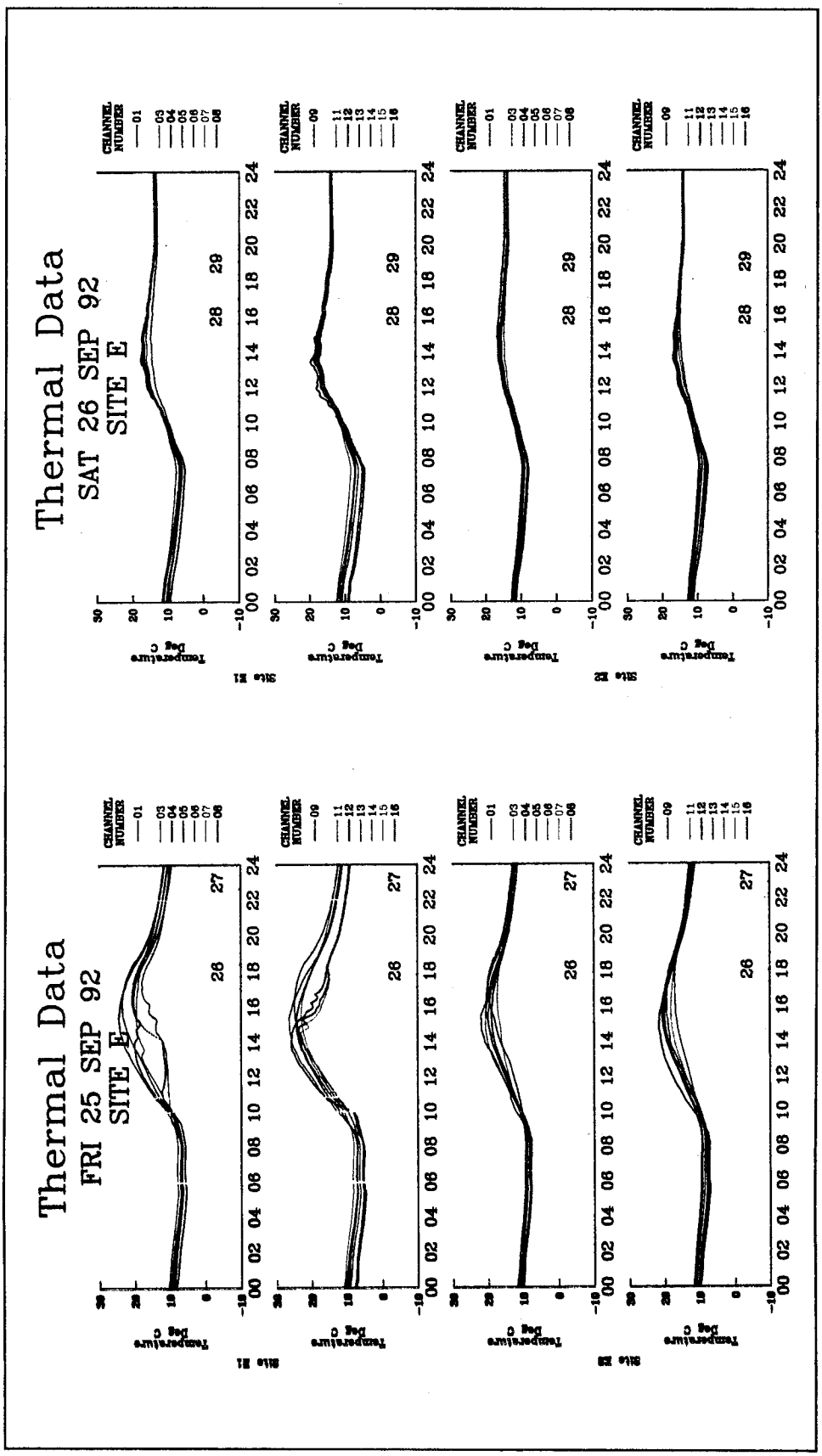

Thermal Data
TUE 15 SEP 92
SITE E
Thermal Data
WED 16 SEP 92
SITE E
Site E1
Site E2
Temperature Deg C
CHANNEL NUMBER

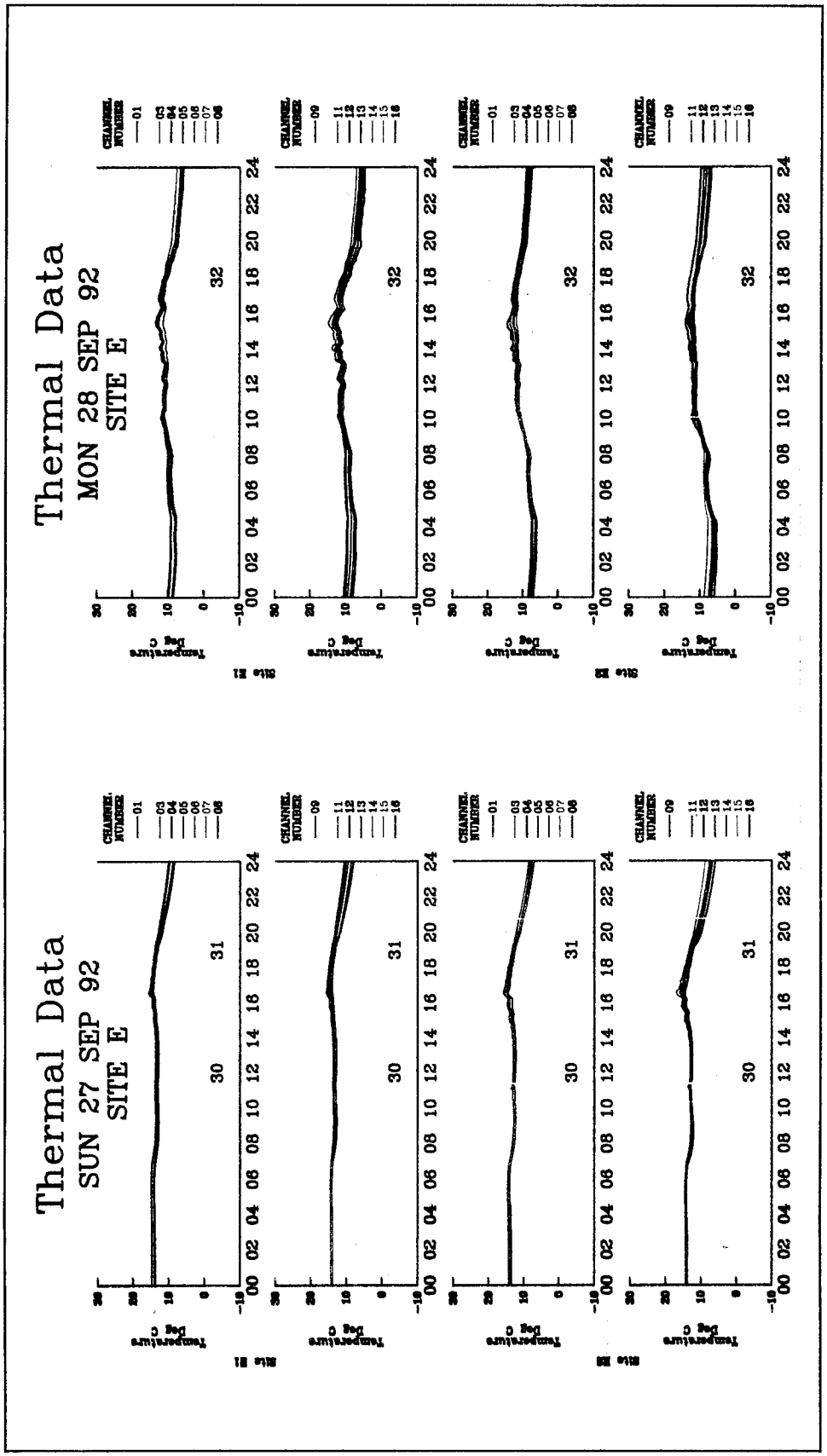

Thermal Data
FRI 18 SEP 92
SITE E
Thermal Data
THUR 17 SEP 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

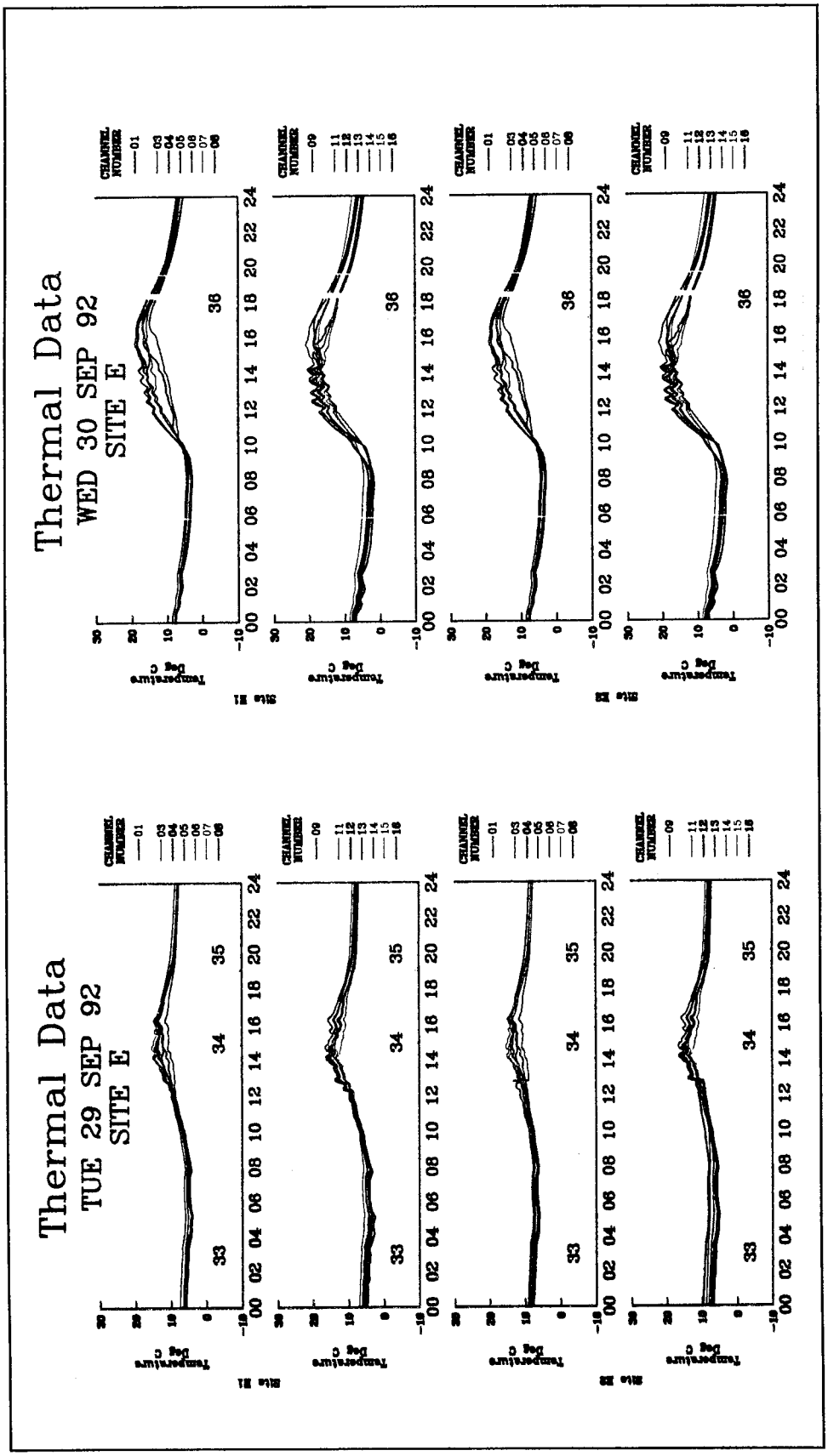

Thermal Data
SUN 20 SEP 92
SITE E
Thermal Data
SAT 19 SEP 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

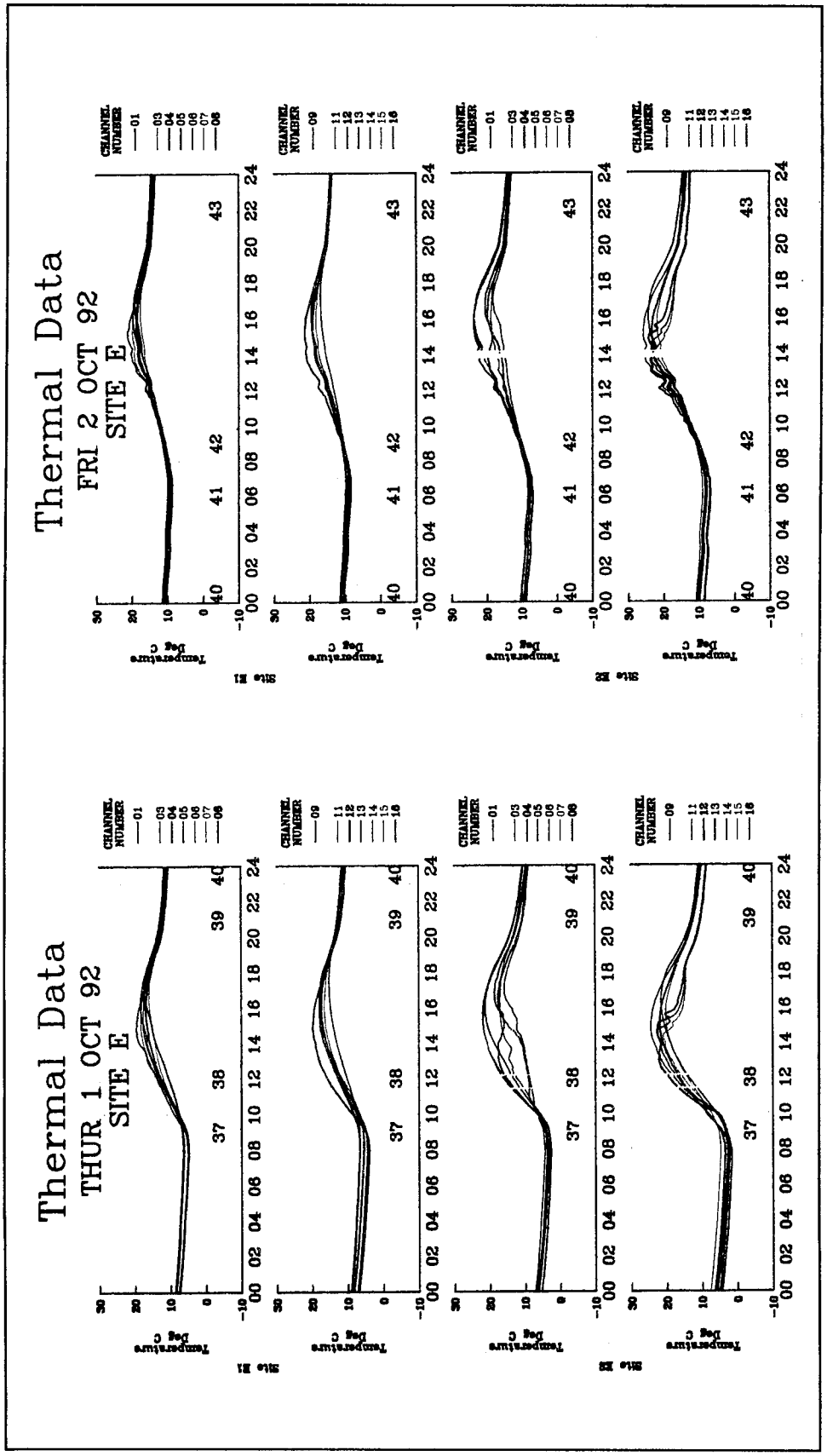

Thermal Data
TUE 22 SEP 92
SITE E
Thermal Data
MON 21 SEP 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2
00 02 04 06 08 10 12 14 16 18 20 22 24
21 22
19 20

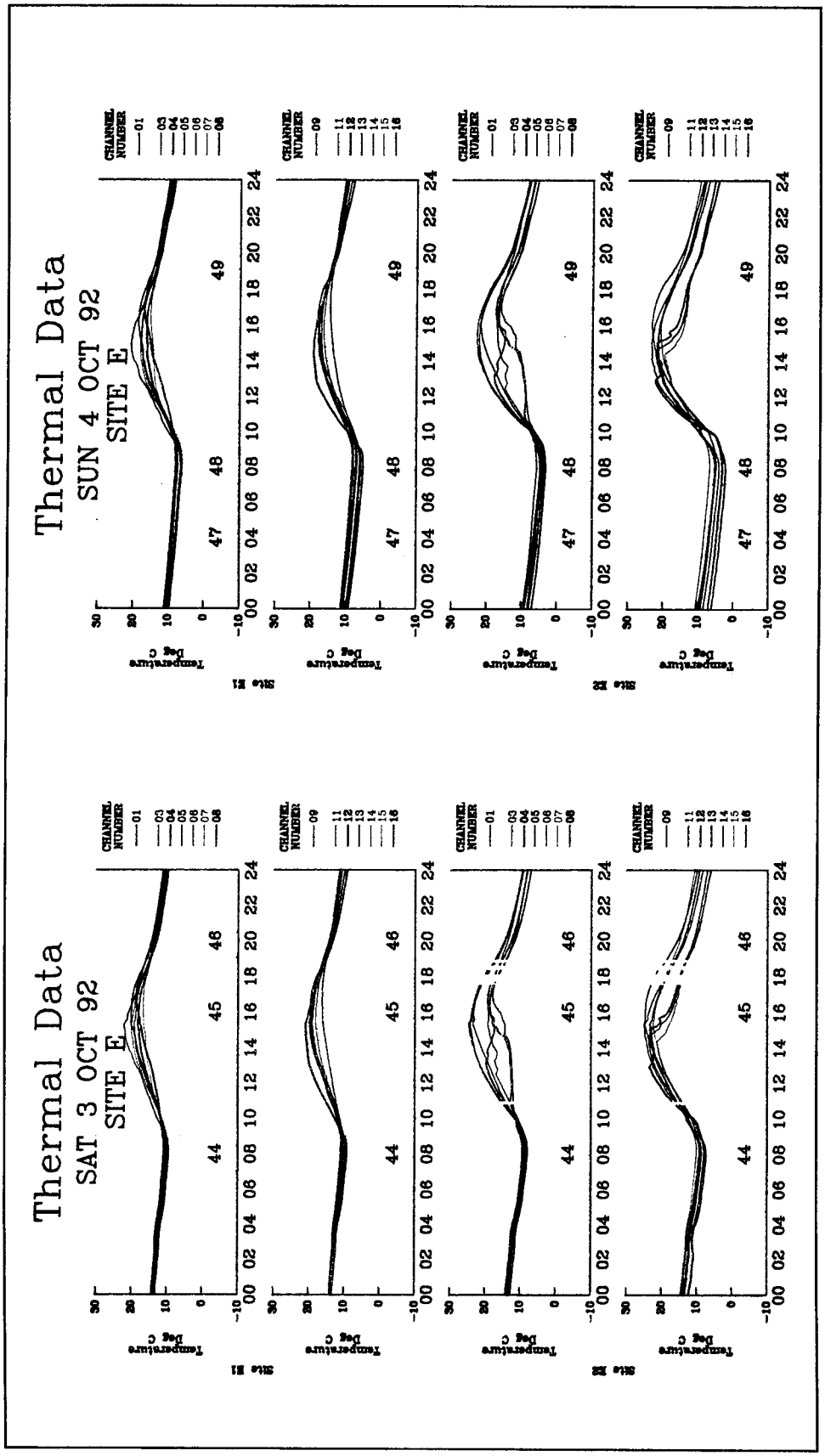

Thermal Data
THU 24 SEP 92
SITE E
Thermal Data
WED 23 SEP 92
SITE E
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
Temperature Deg C
Site E1
Site E2
23
24
25

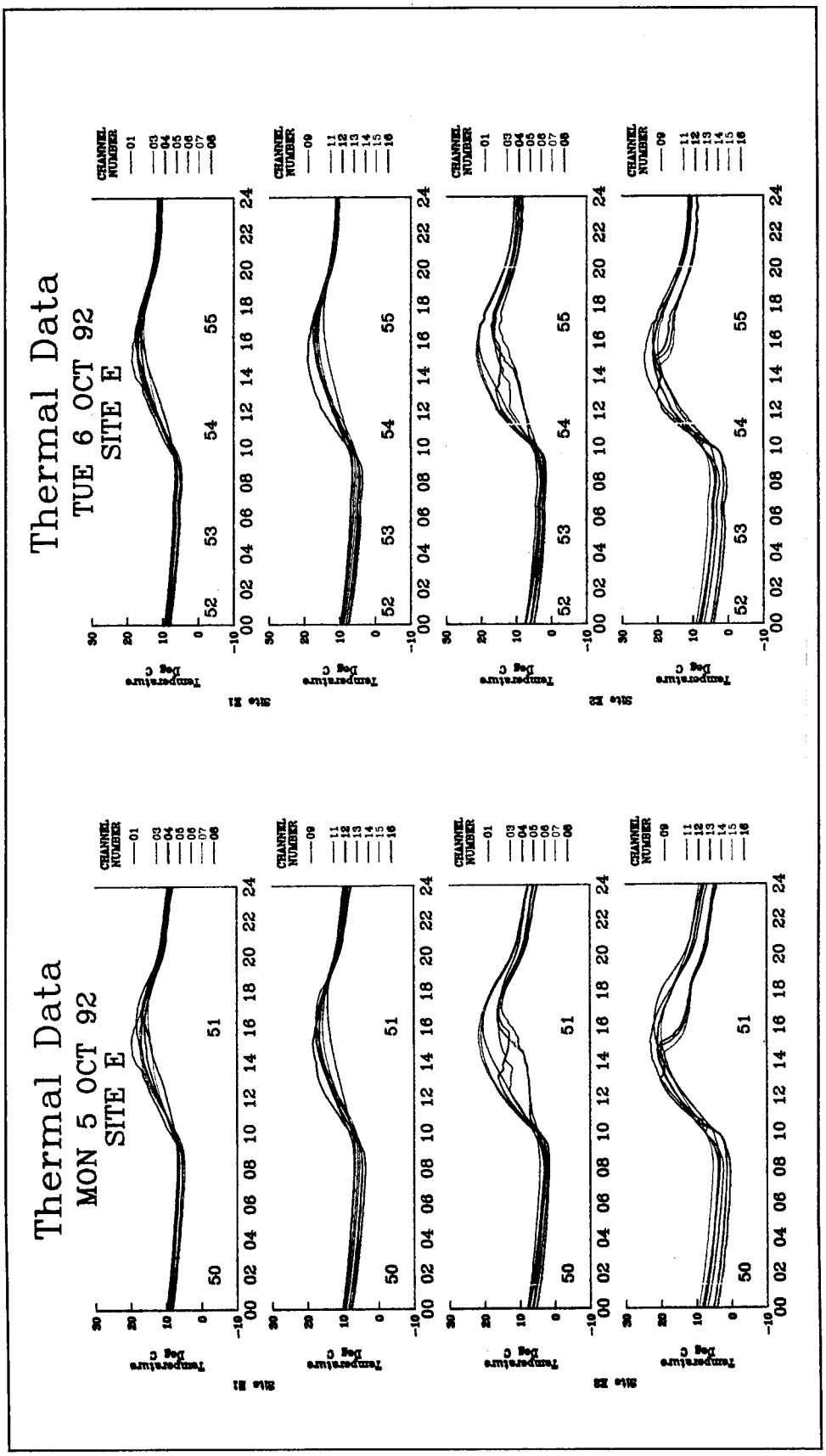

Thermal Data
SAT 26 SEP 92
SITE E
Thermal Data
FRI 25 SEP 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

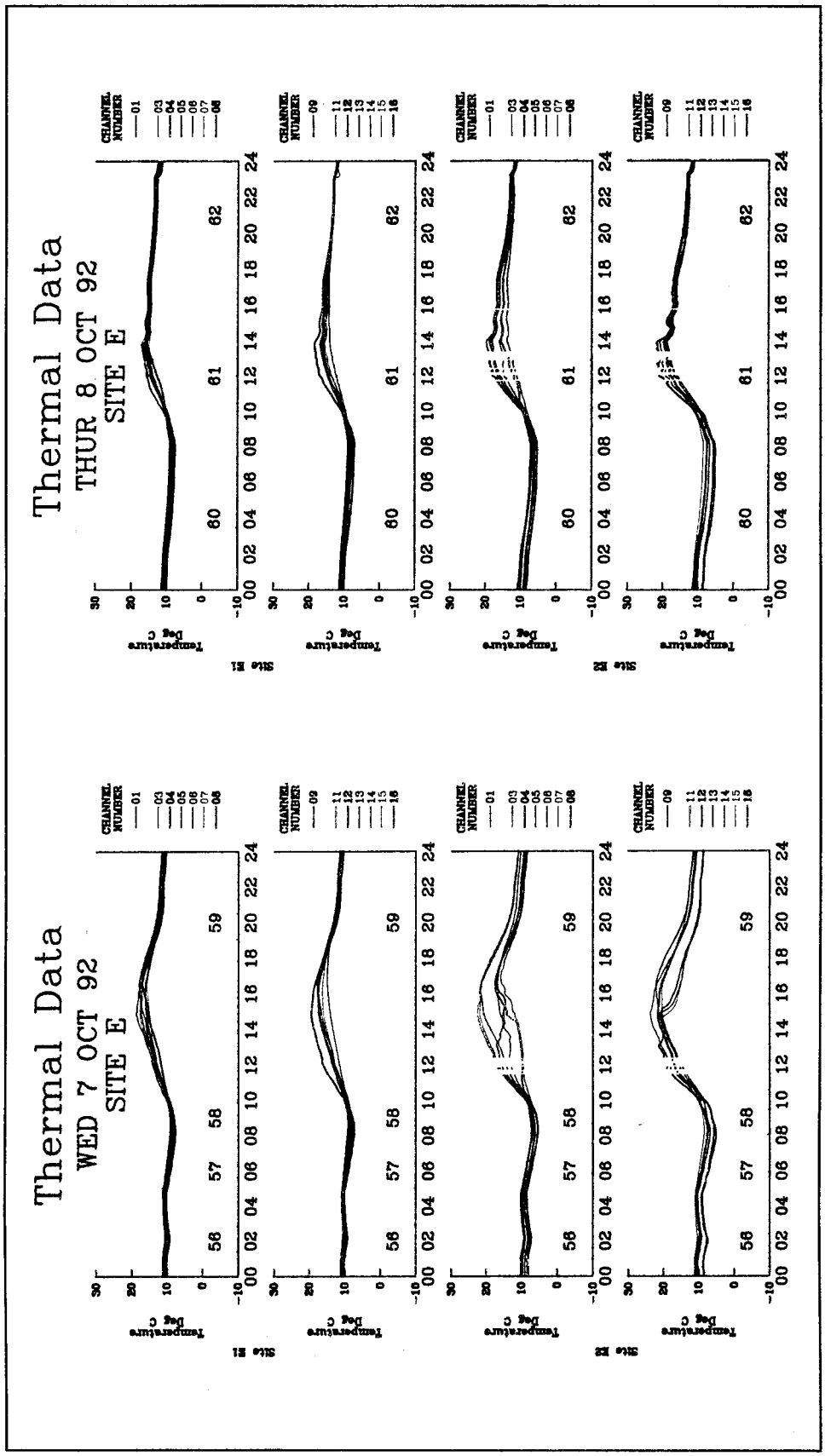

Thermal Data
MON 28 SEP 92
SITE E
Thermal Data
SUN 27 SEP 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E8
30
31
32

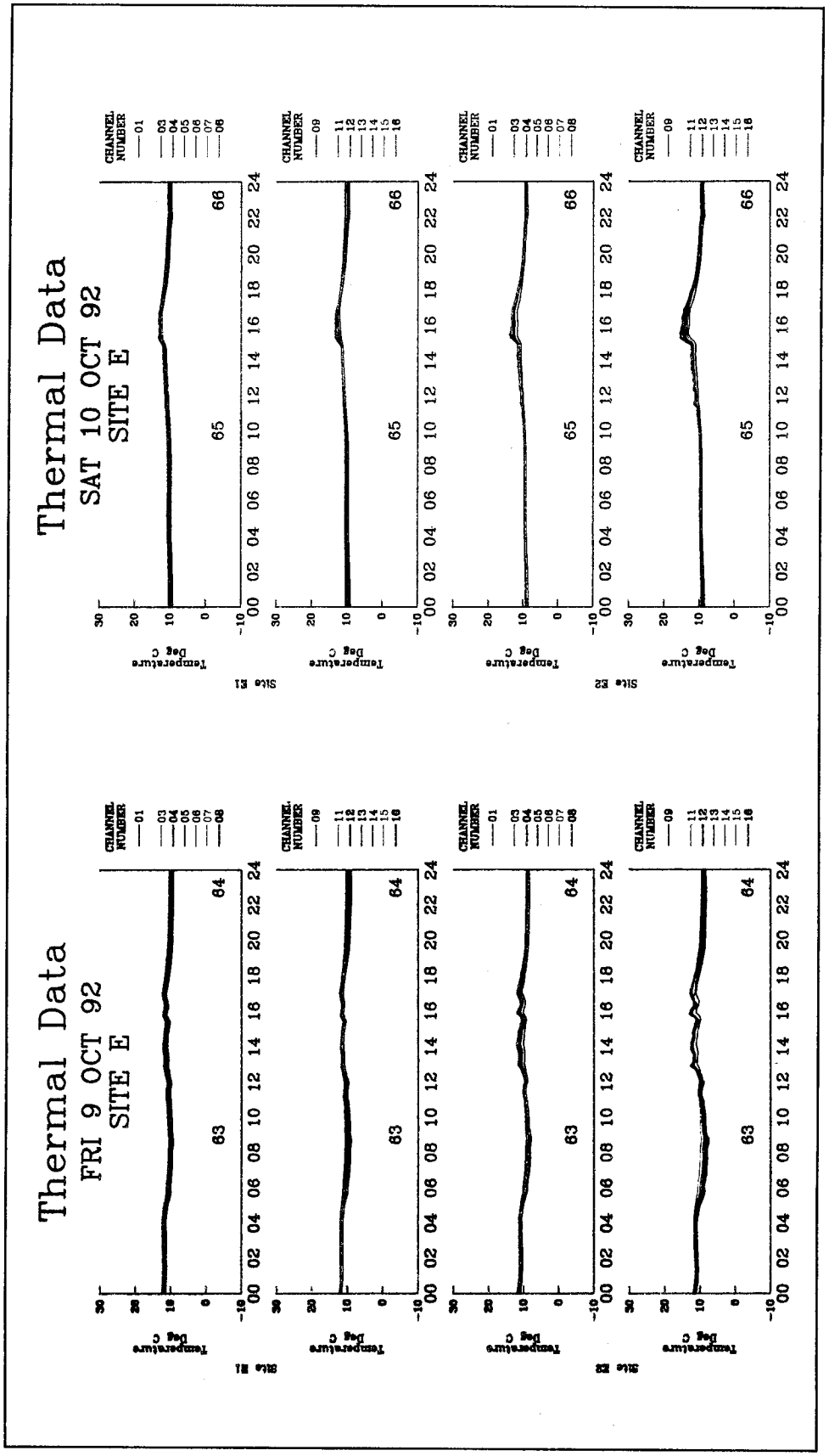

Thermal Data
WED 30 SEP 92
SITE E
Thermal Data
TUE 29 SEP 92
SITE E
Temperature Deg C
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
00 02 04 06 08 10 12 14 16 18 20 22 24
33
34
35
36

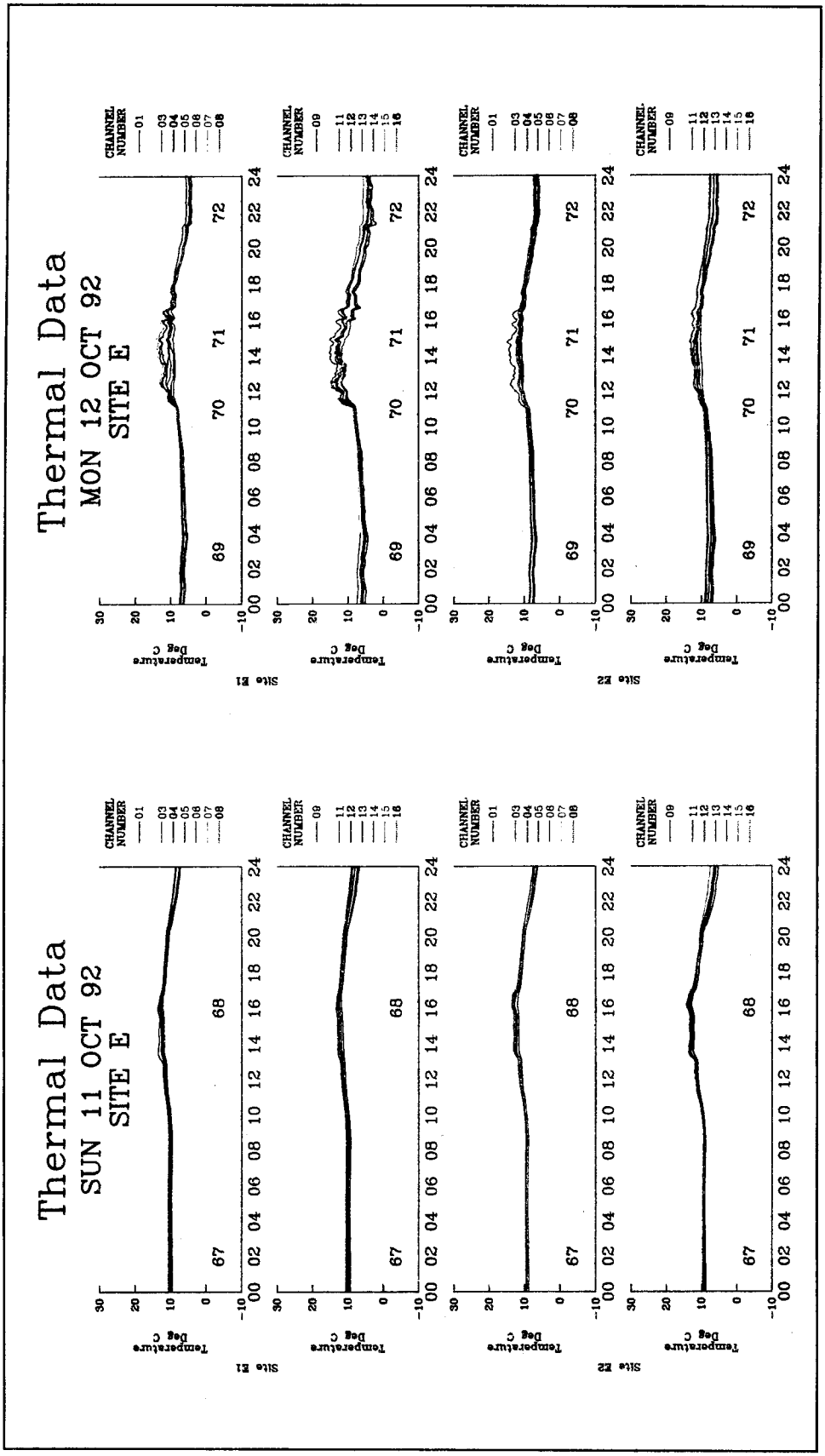

Thermal Data
THUR 1 OCT 92
SITE E
Thermal Data
FRI 2 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2
00 02 04 06 08 10 12 14 16 18 20 22 24
37 38 39 40 41 42 43

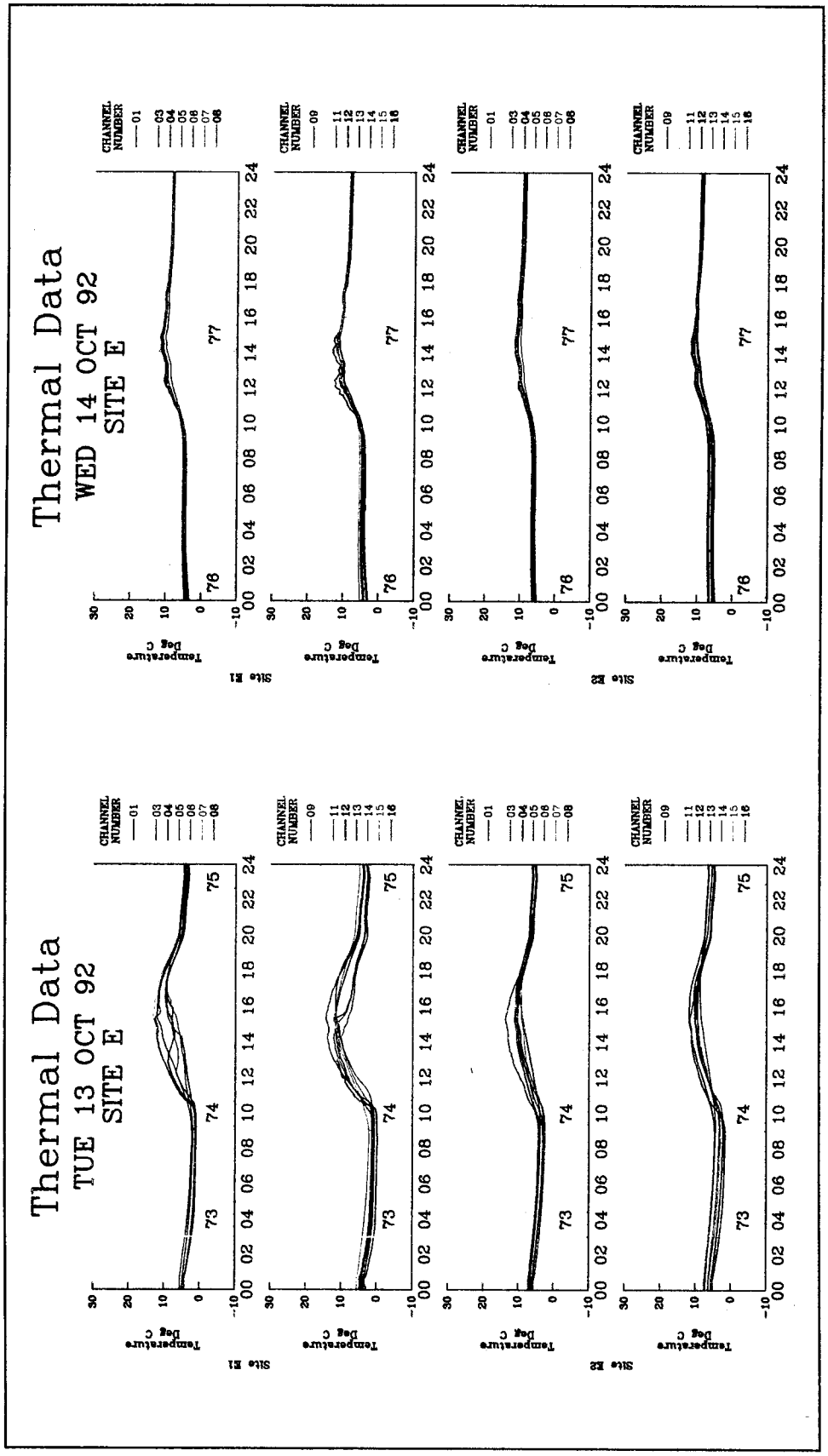

Thermal Data
SUN 4 OCT 92
SITE E
Thermal Data
SAT 3 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

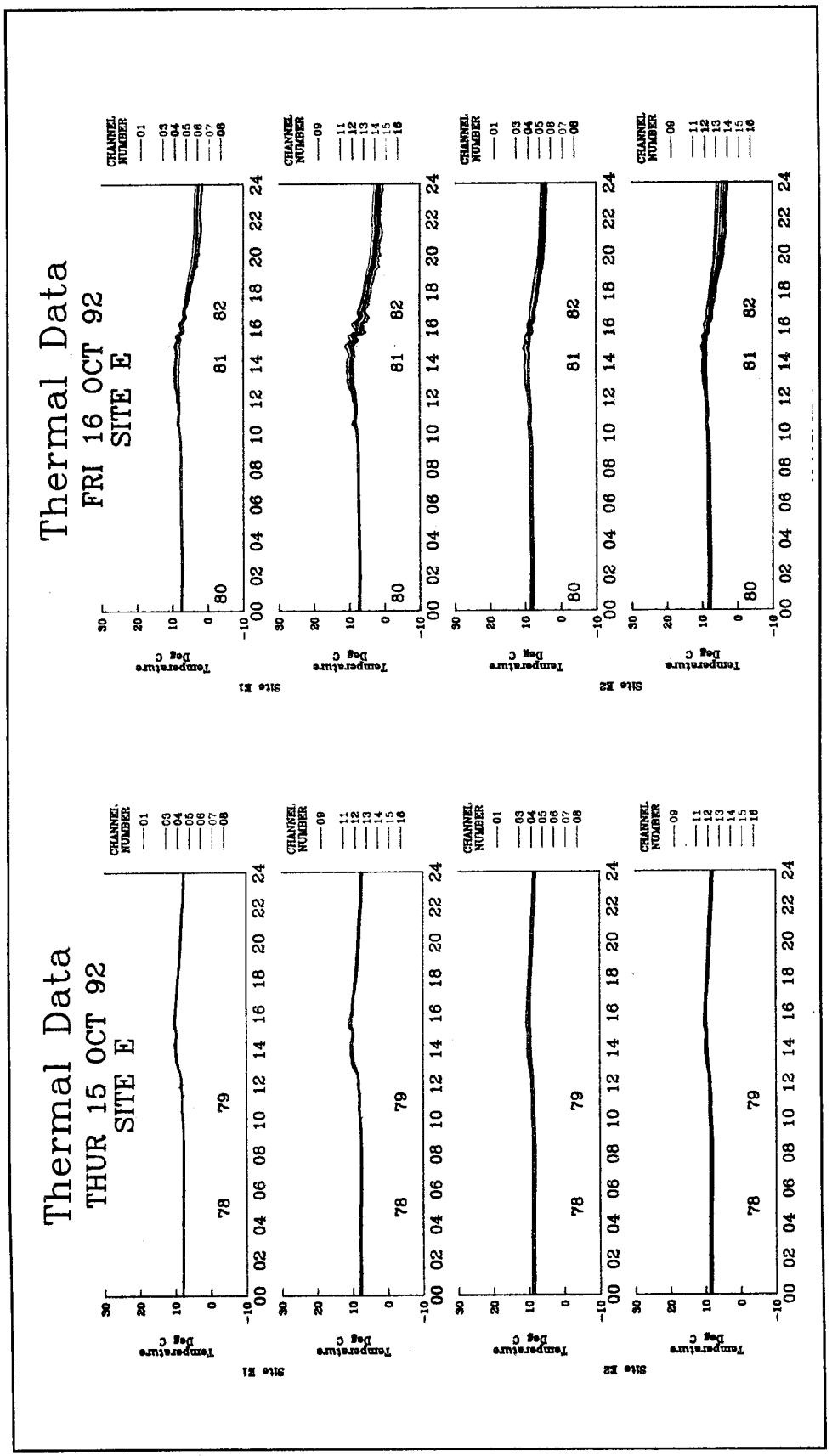

Thermal Data
TUE 6 OCT 92
SITE E
Thermal Data
MON 5 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

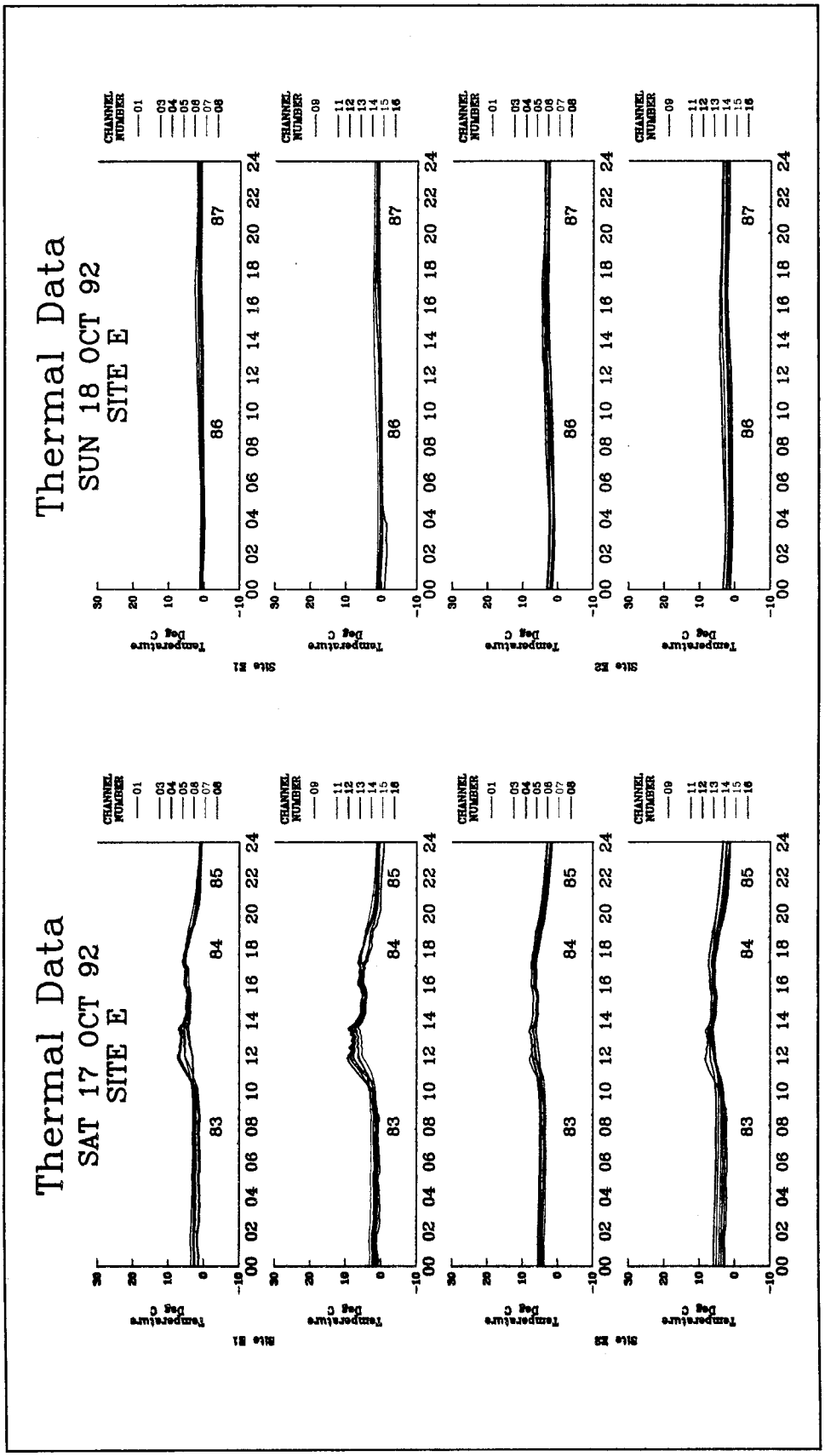

Thermal Data
WED 7 OCT 92
SITE E
Thermal Data
THUR 8 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

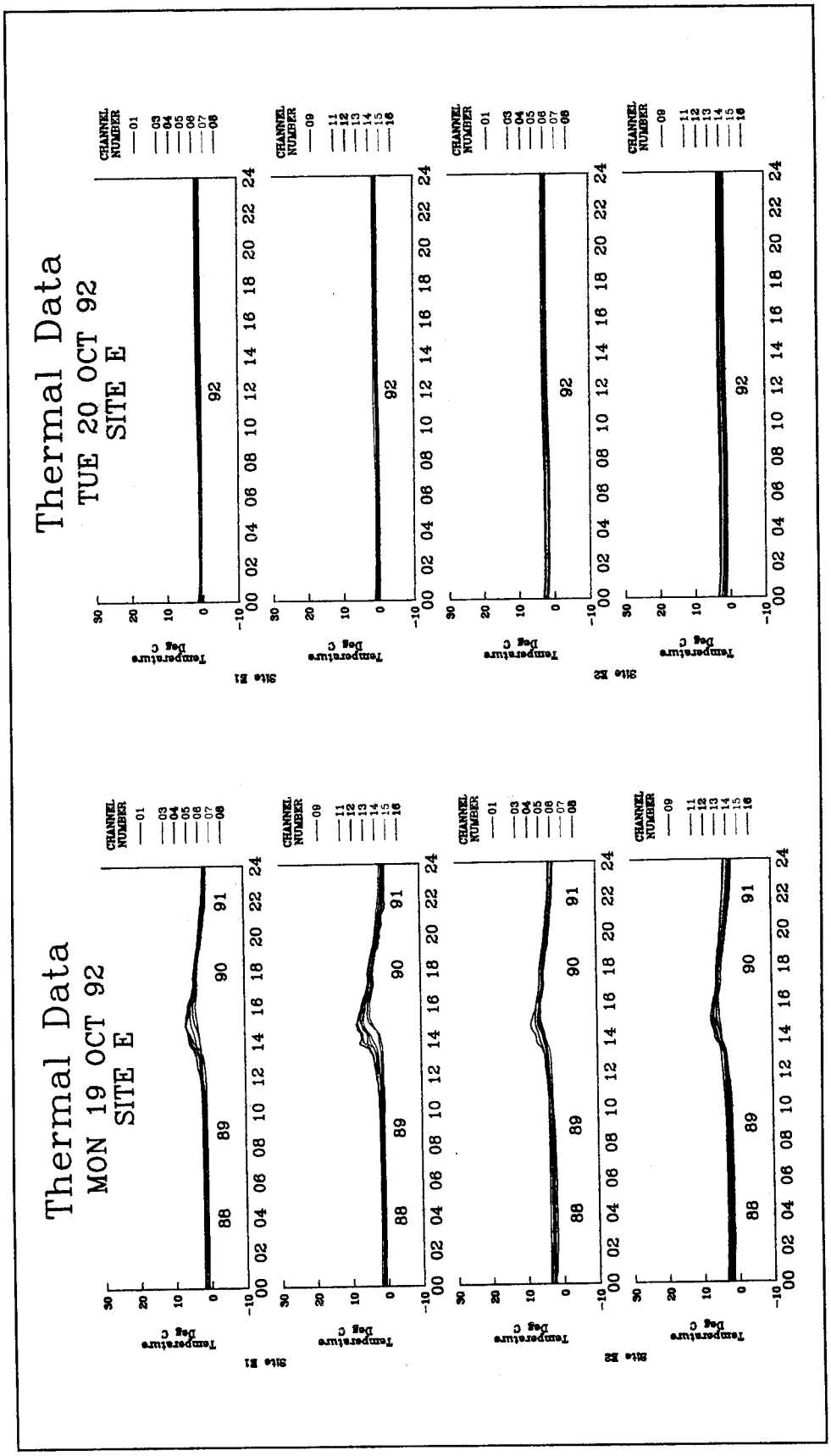

Thermal Data
SAT 10 OCT 92
SITE E
Thermal Data
FRI 9 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

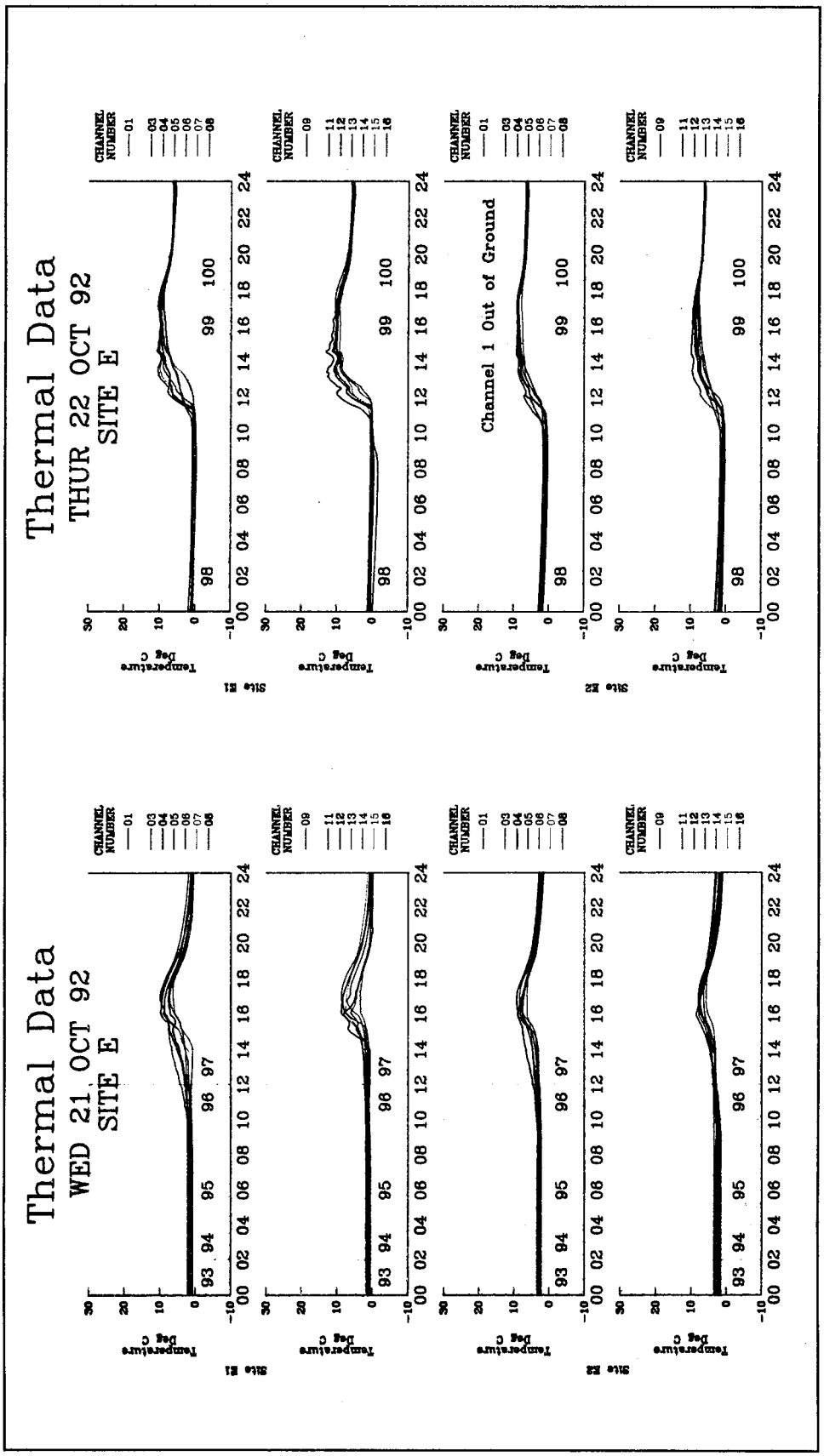

Thermal Data
MON 12 OCT 92
SITE E
Thermal Data
SUN 11 OCT 92
SITE E
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
Temperature Deg C
Site E1
Site E2
69
70
71
72
67
68
00 02 04 06 08 10 12 14 16 18 20 22 24
-10 0 10 20 30

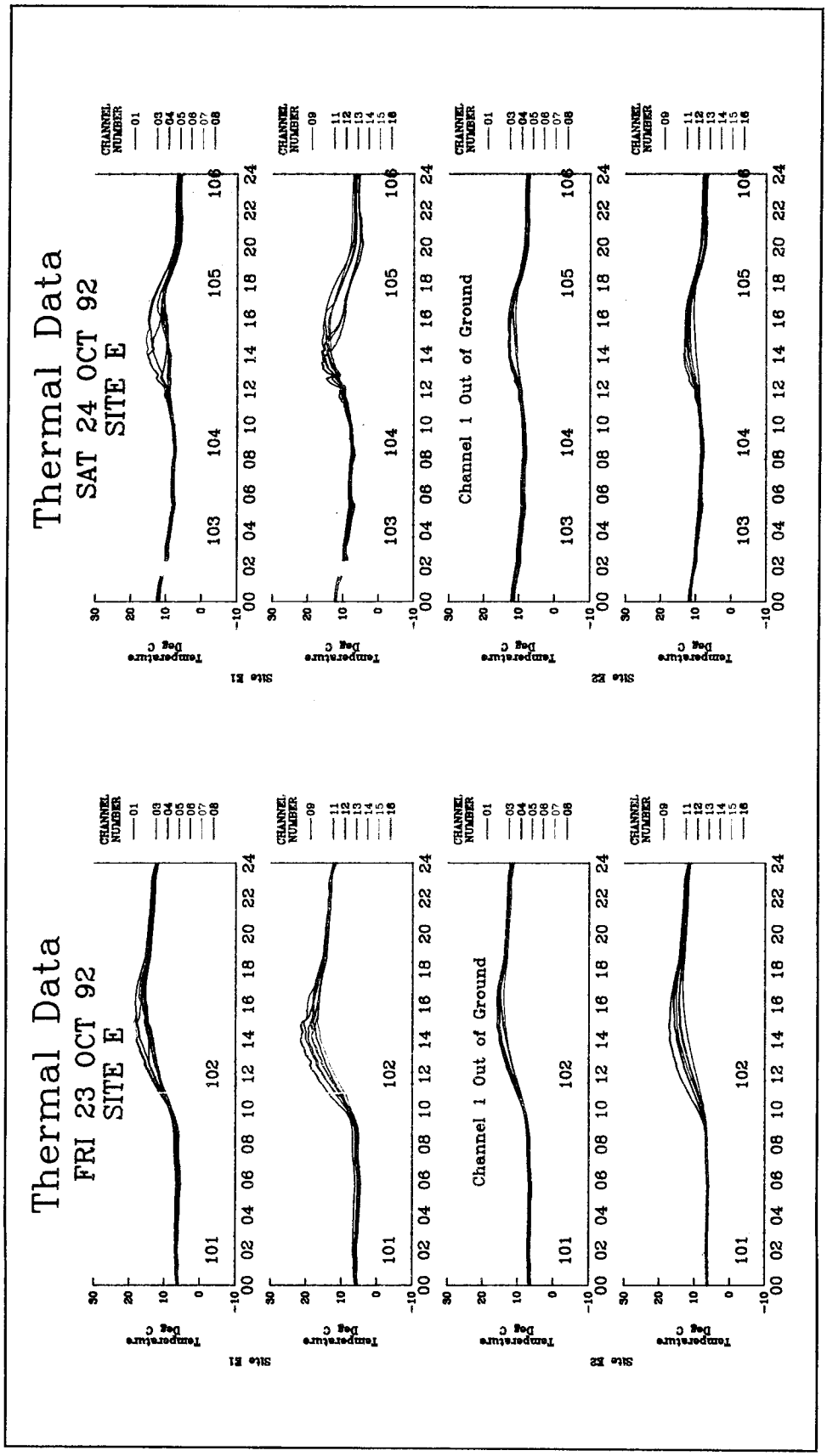

Thermal Data
TUE 13 OCT 92
SITE E
Thermal Data
WED 14 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2

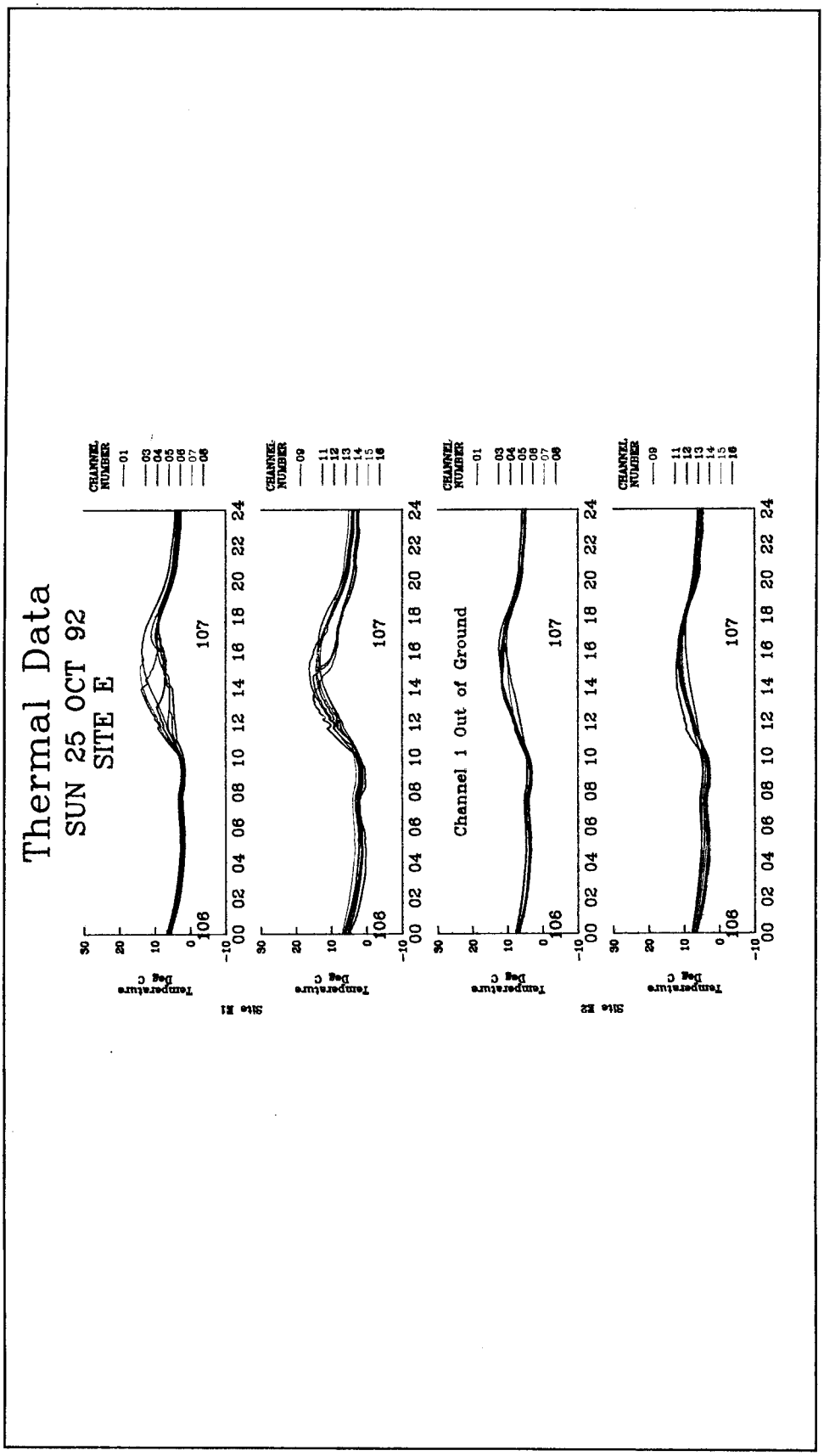

Thermal Data
FRI 16 OCT 92
SITE E
Thermal Data
THUR 15 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2


Thermal Data
SUN 18 OCT 92
SITE E
Thermal Data
SAT 17 OCT 92
SITE E
Site E1
Site E2
Temperature Deg C
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
00 02 04 06 08 10 12 14 16 18 20 22 24
30 20 10 0 -10
83
84
85
86
87


Thermal Data
TUE 20 OCT 92
SITE E
Thermal Data
MON 19 OCT 92
SITE E
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2
92
91
90
89
88


Thermal Data
THUR 22 OCT 92
SITE E
Thermal Data
WED 21 OCT 92
SITE E
Channel 1 Out of Ground
CHANNEL NUMBER
Temperature Deg C
Site E1
Site E2


Thermal Data
SAT 24 OCT 92
SITE E
Thermal Data
FRI 23 OCT 92
SITE E
Channel 1 Out of Ground
Site E1
Site E2
Temperature Deg C
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
101
102
103
104
105
106


Thermal Data
SUN 25 OCT 92
SITE E
Channel 1 Out of Ground
Site E1
Site E2
Temperature Deg C
CHANNEL NUMBER
01
03
04
05
06
07
08
09
11
12
13
14
15
16
106
107
00 02 04 06 08 10 12 14 16 18 20 22 24
30 20 10 0 -10

Appendix B
Photographs of Thermistor and Staring Radiometer Sites

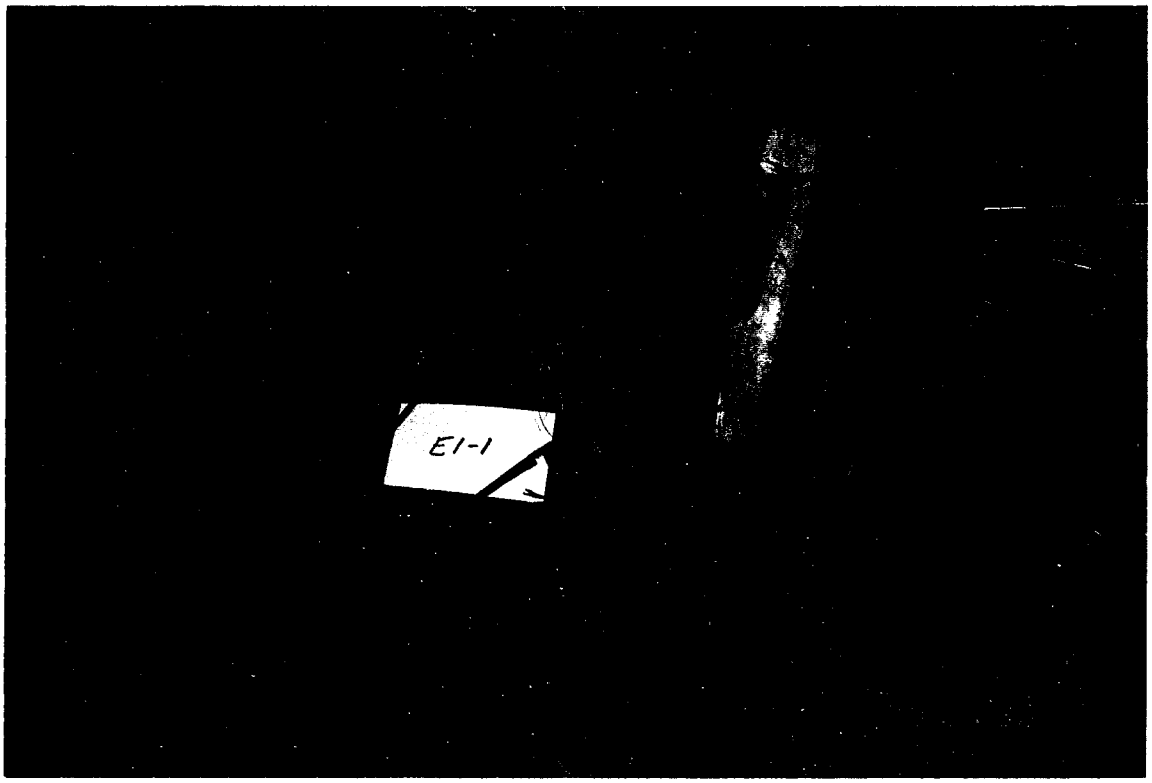


Figure B1. Thermistor Array E1, Channel 1

Figure B2. Thermistor Array E1, Channel 2

Figure B3. Thermistor Array E1, Channel 3

Figure B4. Thermistor Array E1, Channel 4

Figure B5. Thermistor Array E1, Channel 5

Figure B6. Thermistor Array E1, Channel 6

Figure B7. Thermistor Array E1, Channel 7

Figure B8. Thermistor Array E1, Channel 8

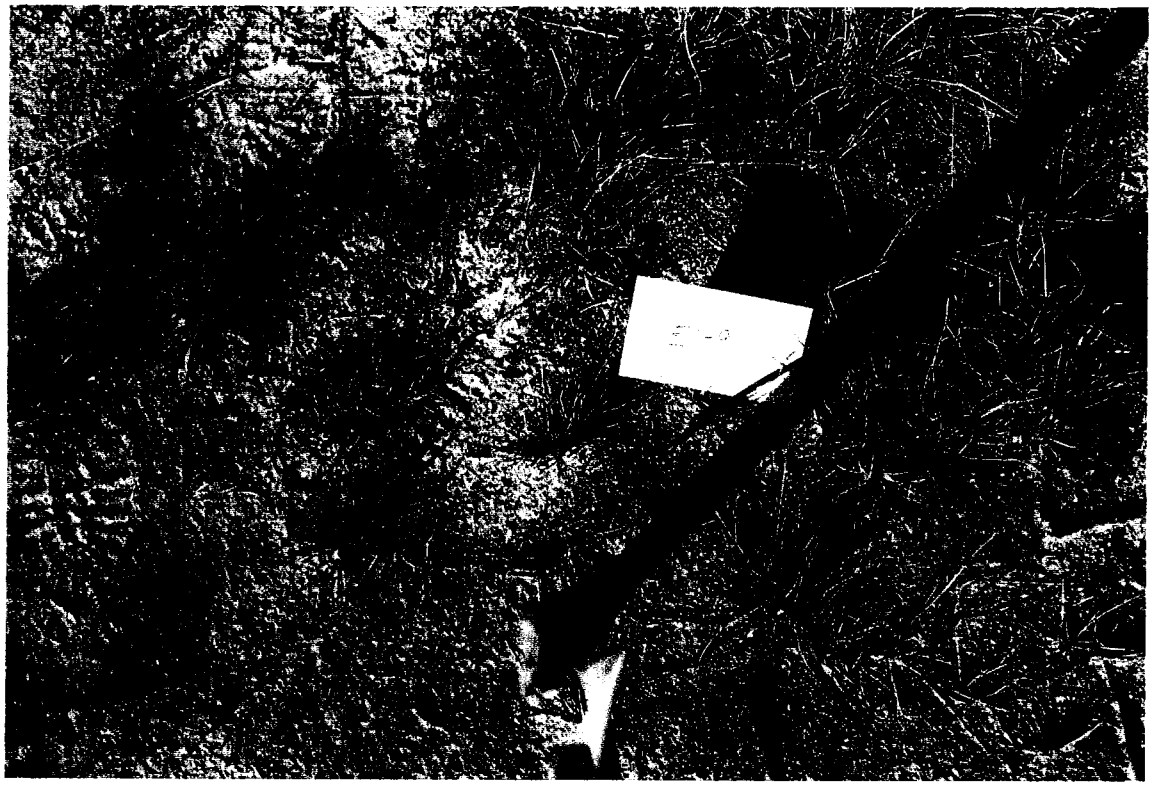


Figure B9. Thermistor Array E1, Channel 9

Figure B10. Thermistor Array E1, Channel 10

Figure B11. Thermistor Array E1, Channel 11

Figure B12. Thermistor Array E1, Channel 12

Figure B13. Thermistor Array E1, Channel 13

Figure B14. Thermistor Array E1, Channel 14

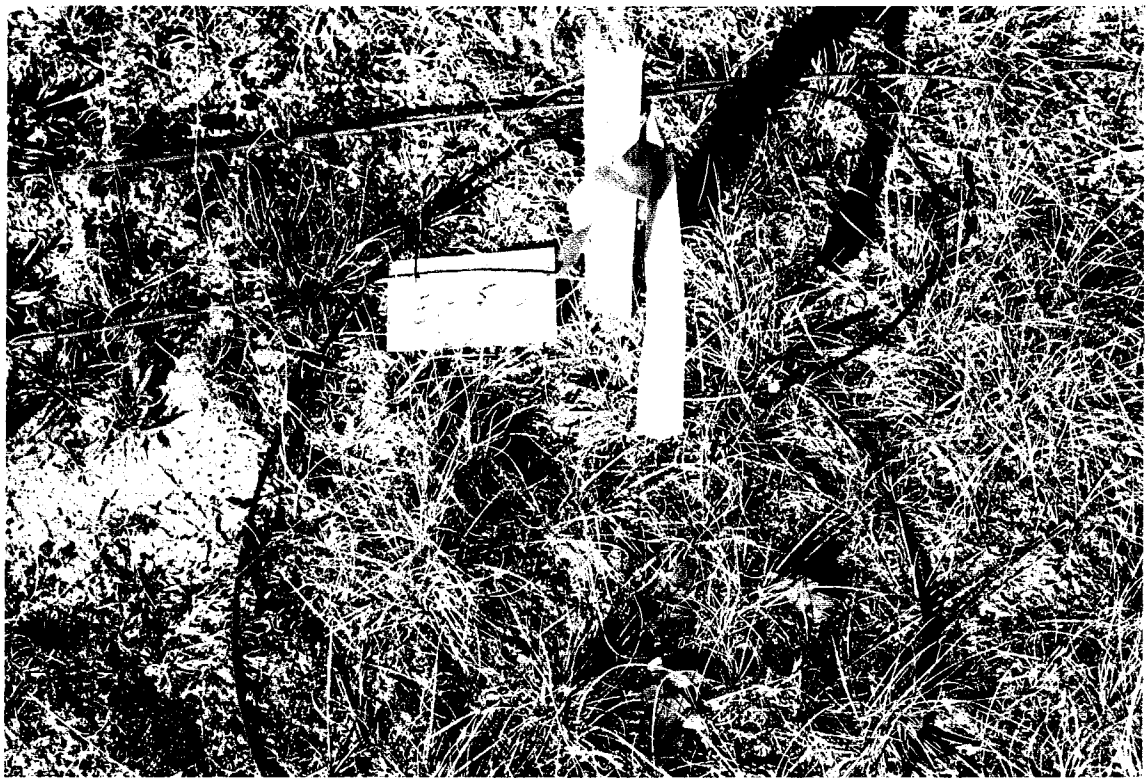


Figure B15. Thermistor Array E1, Channel 15

Figure B16. Thermistor Array E1, Channel 16

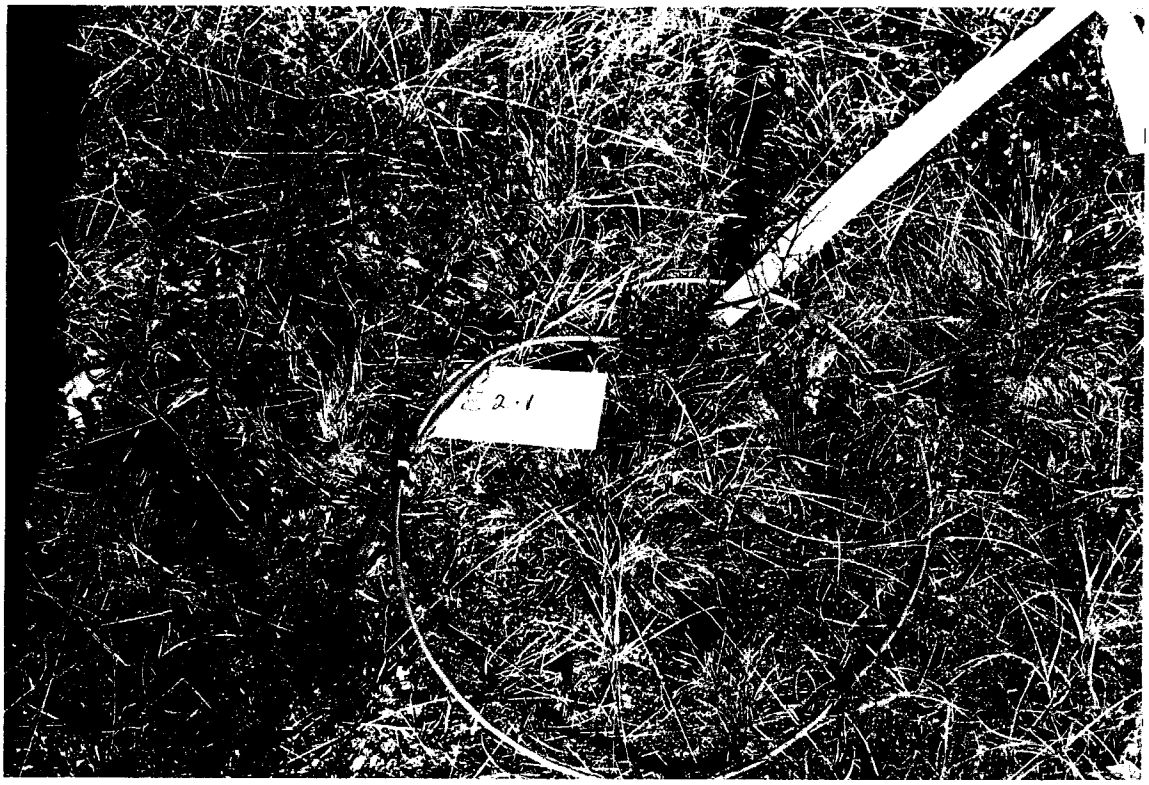


Figure B17. Thermistor Array E2, Channel 1

Figure B18. Thermistor Array E2, Channel 2

Figure B19. Thermistor Array E2, Channel 3

Figure B20. Thermistor Array E2, Channel 4

Figure B21. Thermistor Array E2, Channel 5

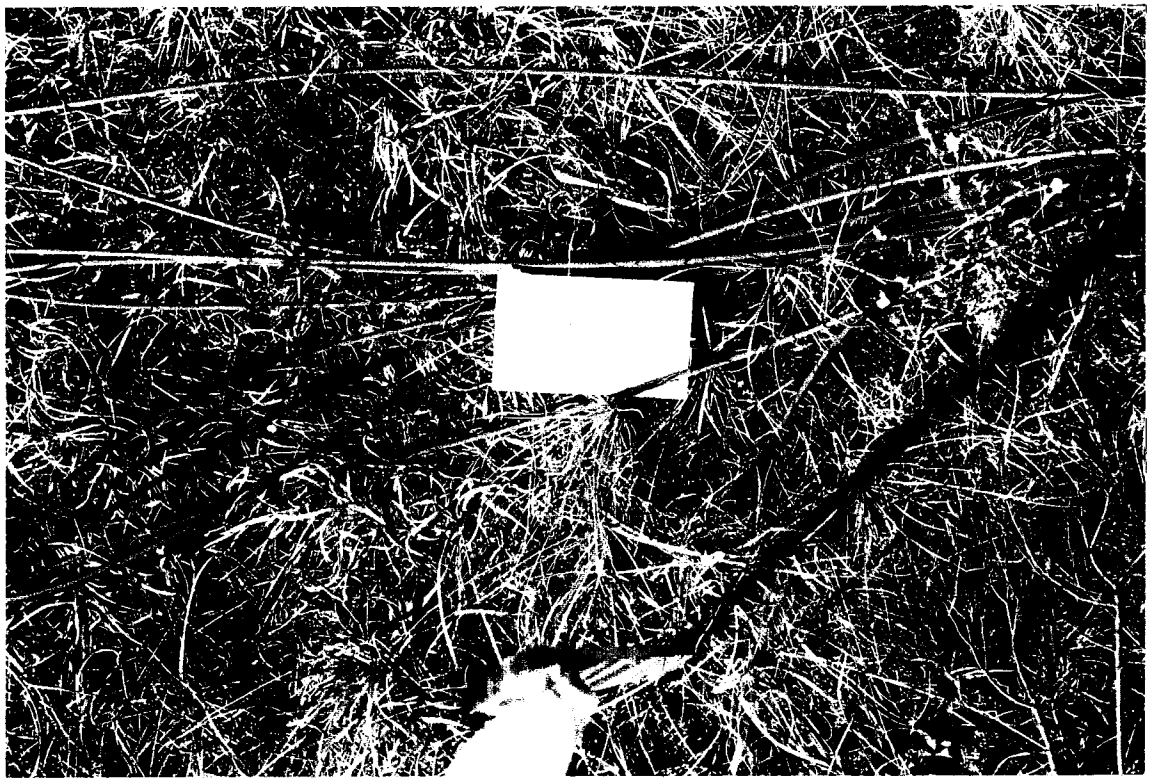


Figure B22. Thermistor Array E2, Channel 6

Figure B23. Thermistor Array E2, Channel 7

Figure B24. Thermistor Array E2, Channel 8

Figure B25. Thermistor Array E2, Channel 10

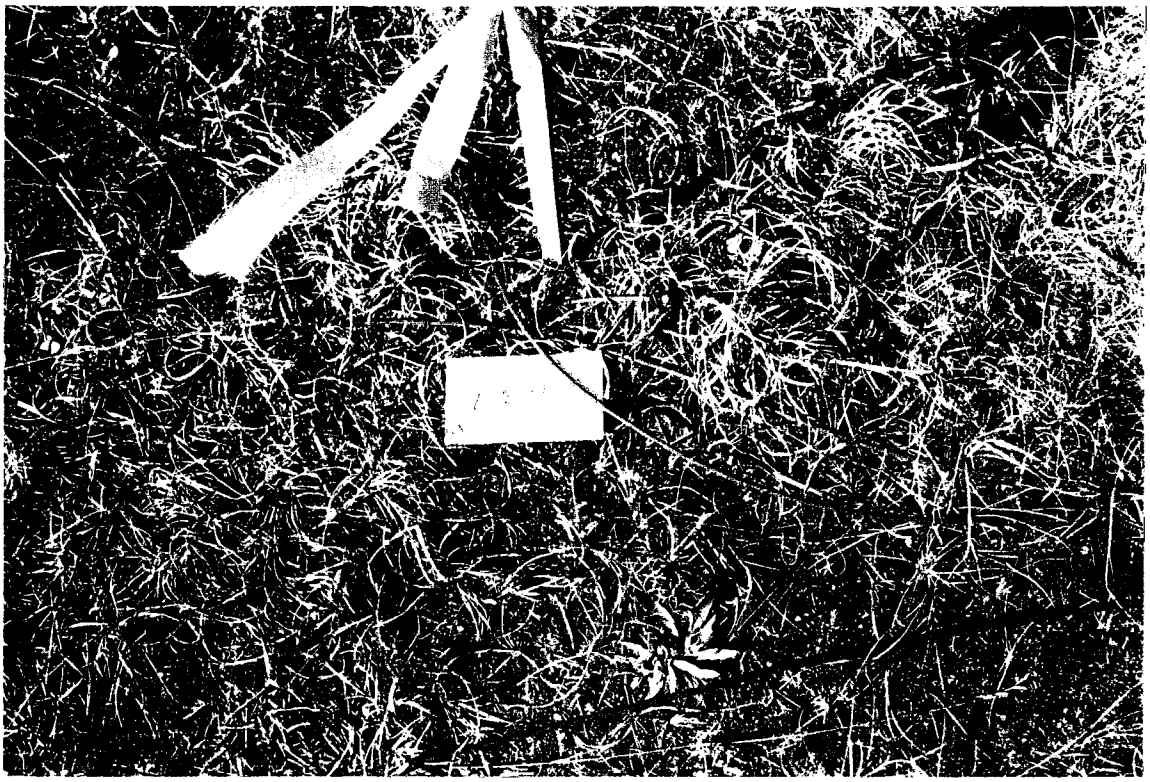


Figure B26. Thermistor Array E2, Channel 11

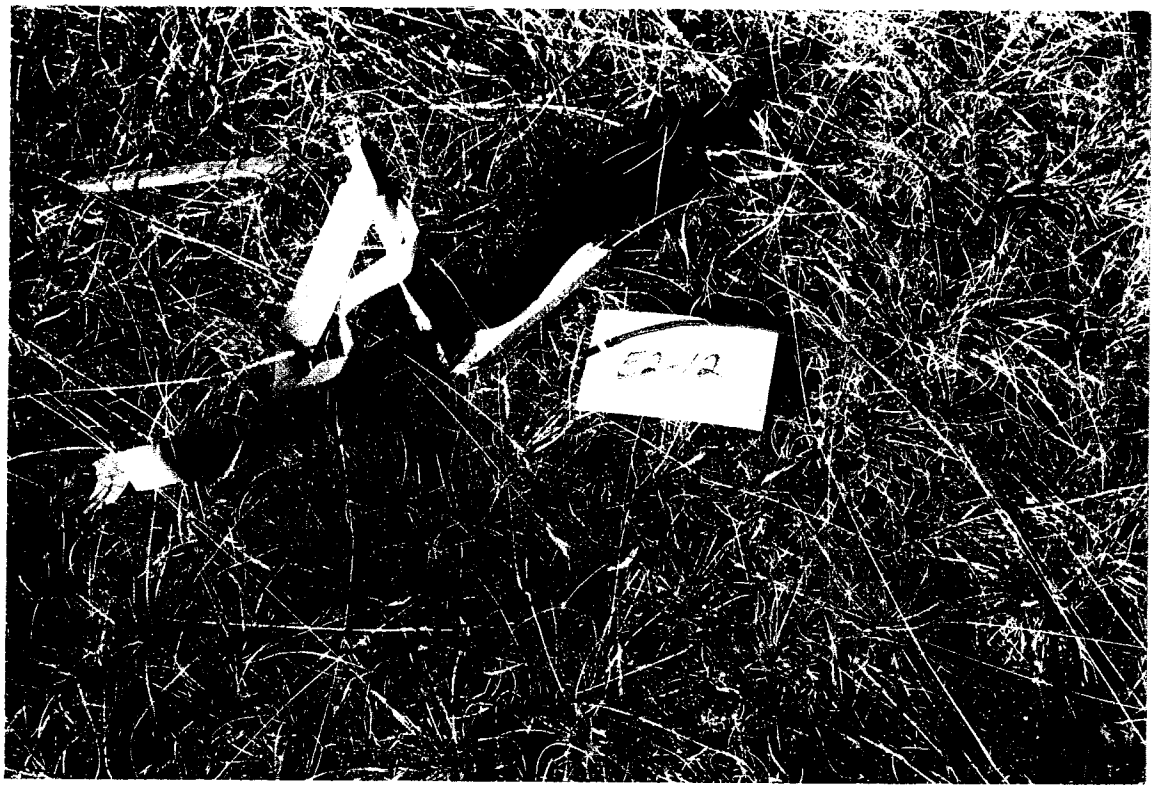


Figure B27. Thermistor Array E2, Channel 12

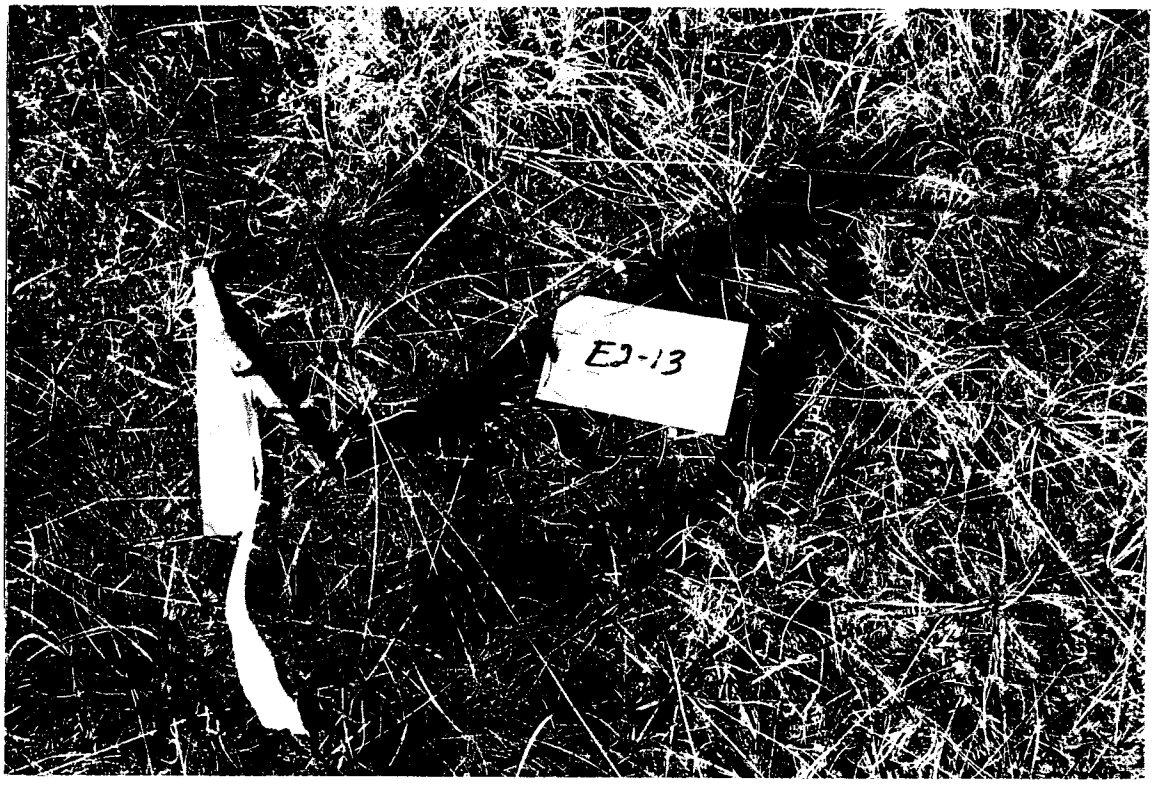


Figure B28. Thermistor Array E2, Channel 13

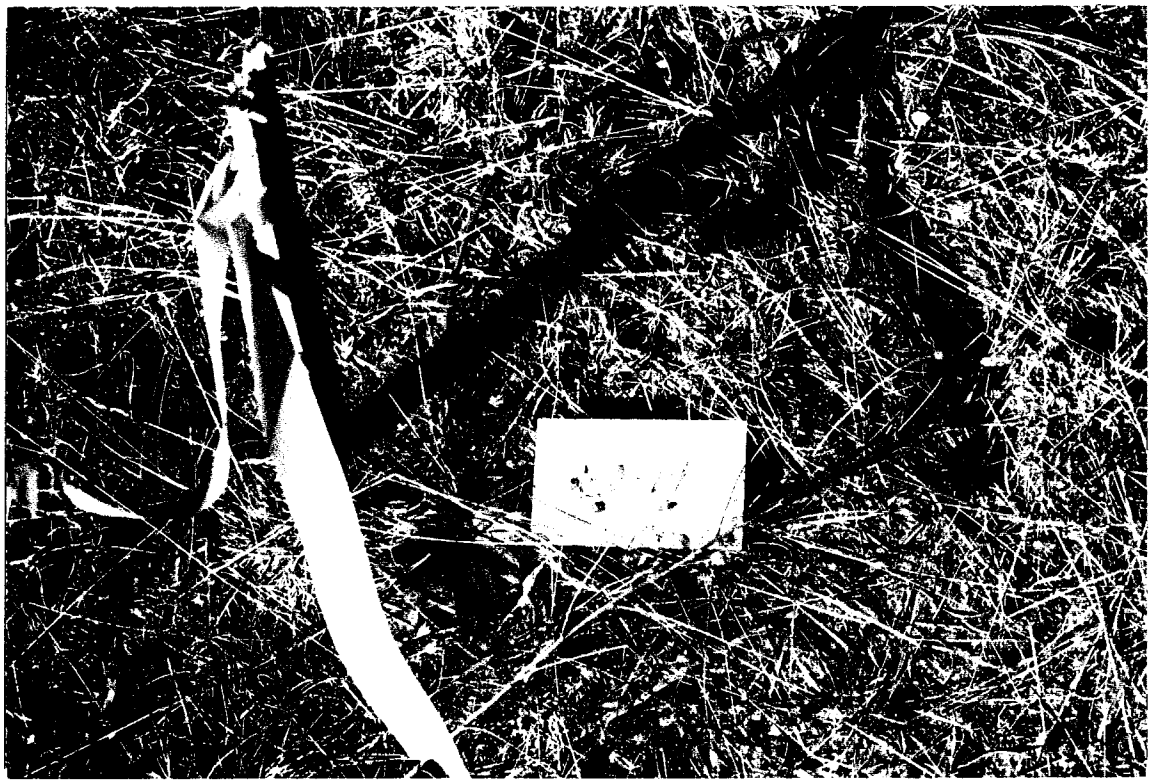


Figure B29. Thermistor Array E2, Channel 14

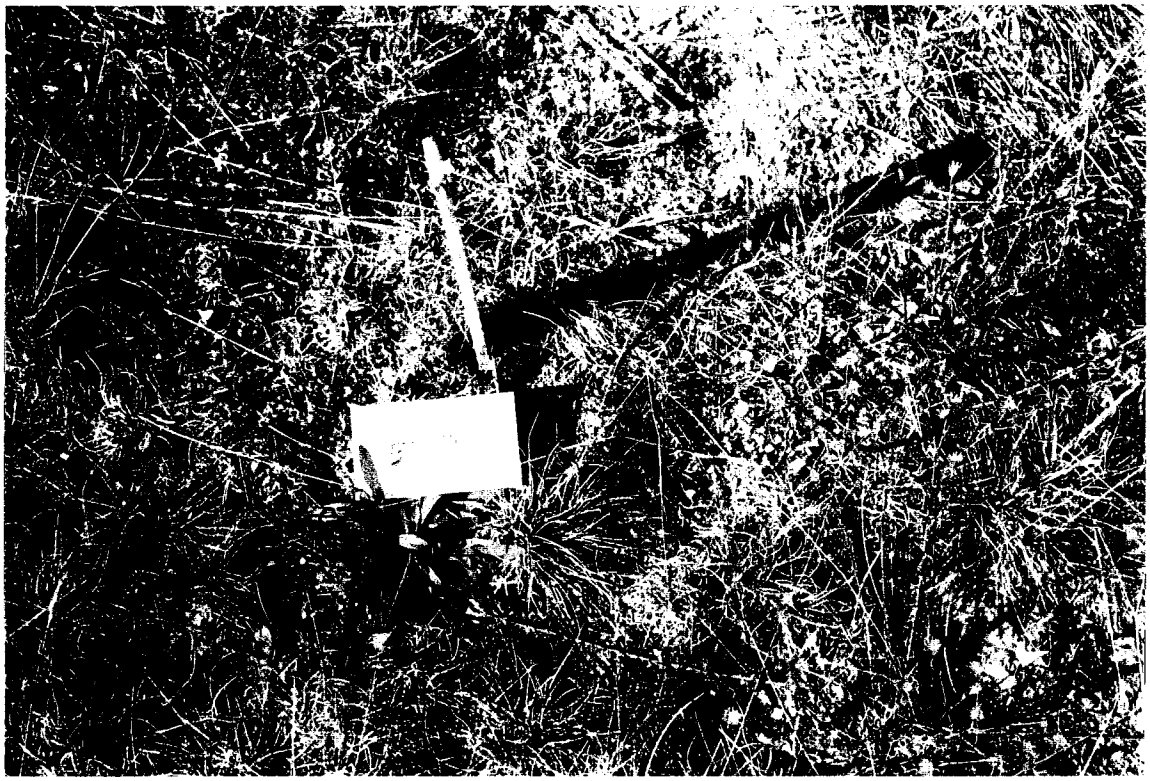


Figure B30. Thermistor Array E2, Channel 15

Figure B31. Thermistor Array E2, Channel 16

Figure B32. Staring radiometer Array D1, Channel 1

Figure B33. Staring radiometer Array D1, Channel 2

Figure B34. Staring Radiometer Array D1, Channel 3

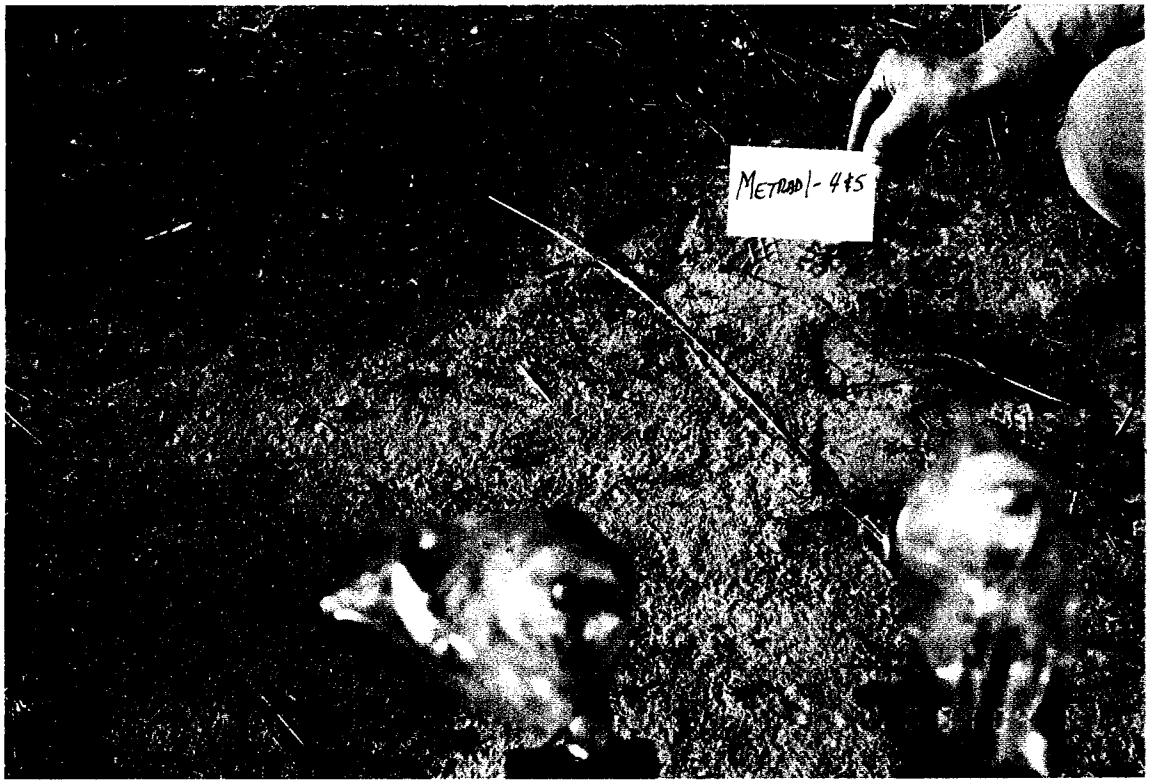


Figure B35. Staring radiometer Array D1, Channels 4 and 5

Figure B36. Staring radiometer Array D1, Channel 6

Figure B37. Staring radiometer Array D1, Channel 7

Figure B38. Staring radiometer Array D1, Channel 8

Figure B39. Staring radiometer Array D2, Channel 1

Figure B40. Staring radiometer Array D2, Channel 2

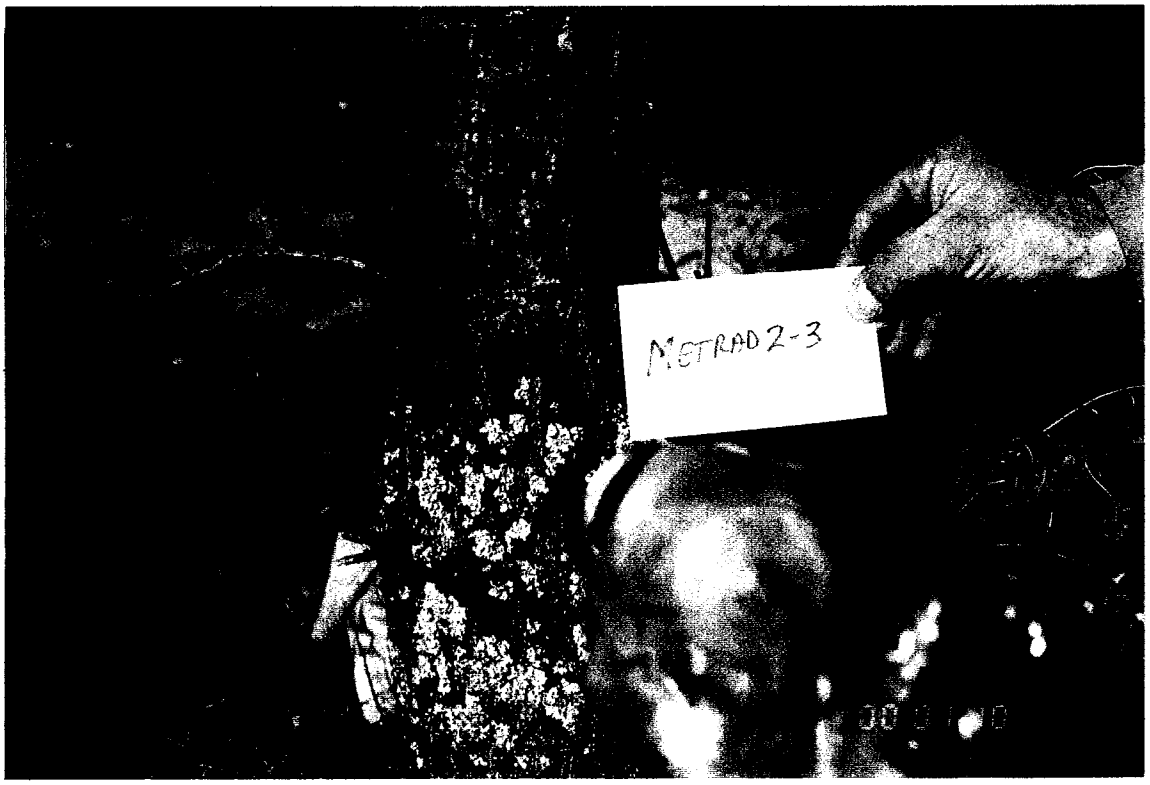


Figure B41. Staring radiometer Array D2, Channel 3

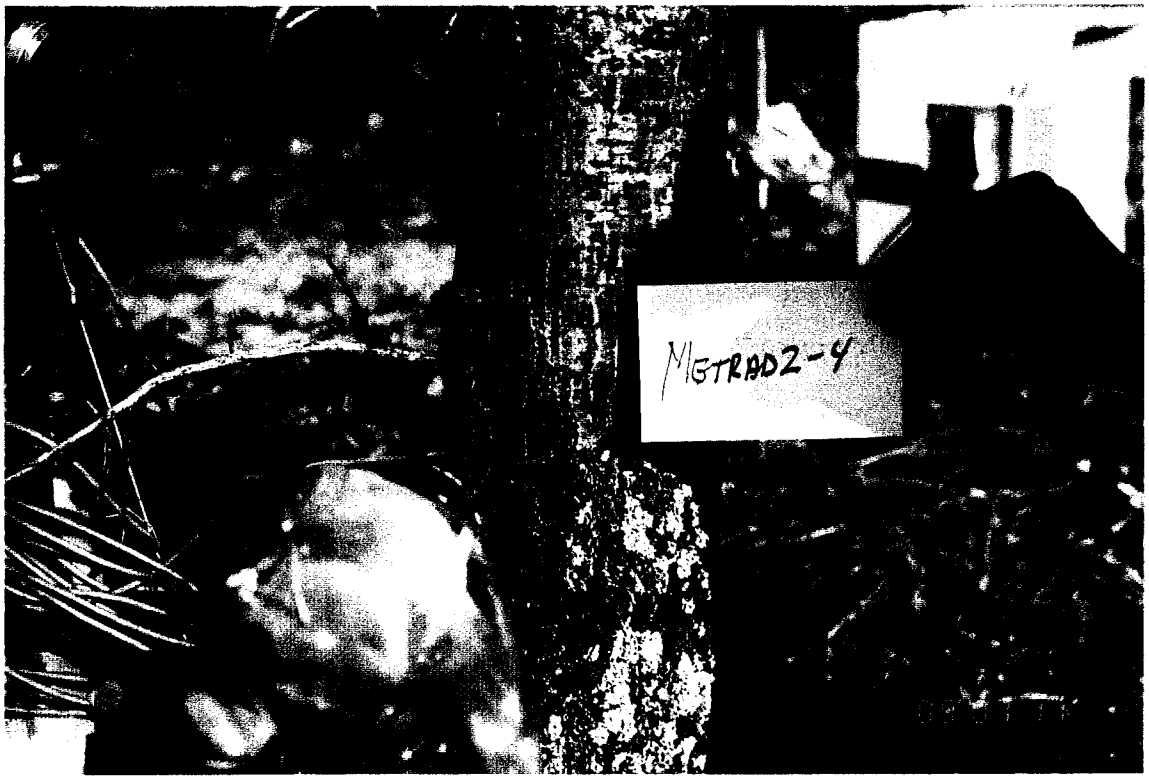


Figure B42. Staring radiometer Array D2, Channel 4

Figure B43. Staring radiometer Array D2, Channel 5

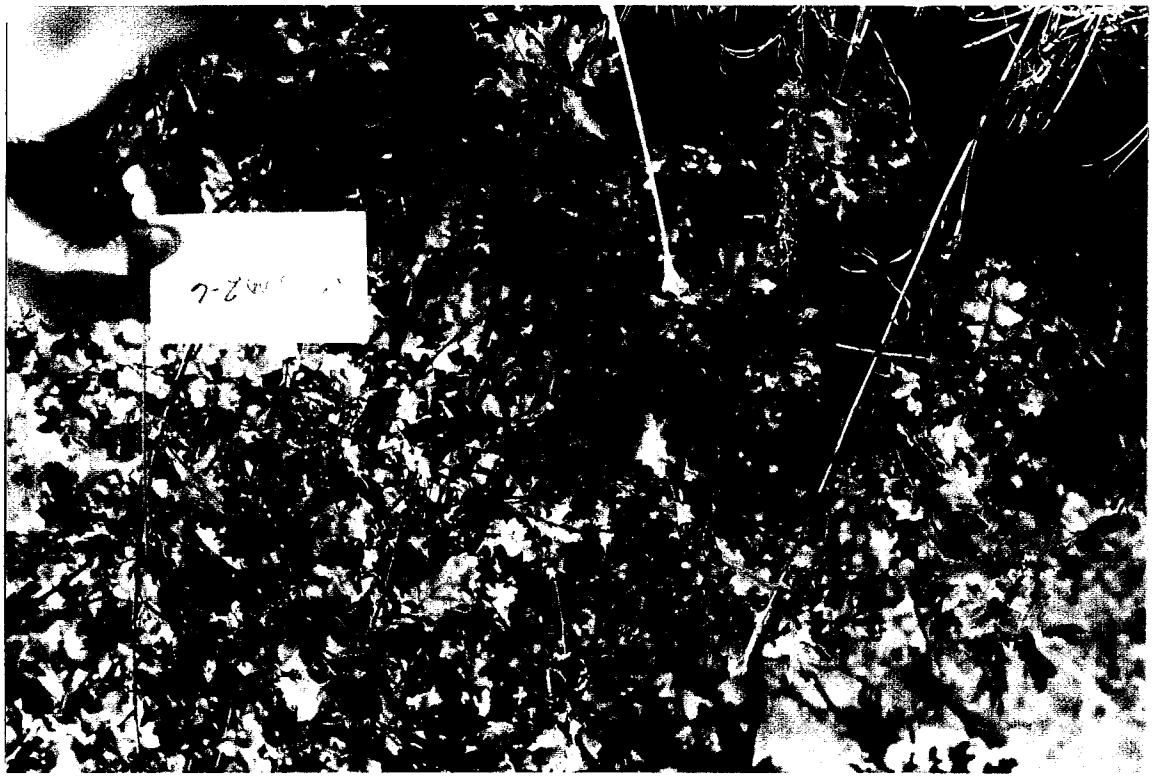


Figure B44. Staring radiometer Array D2, Channel 6

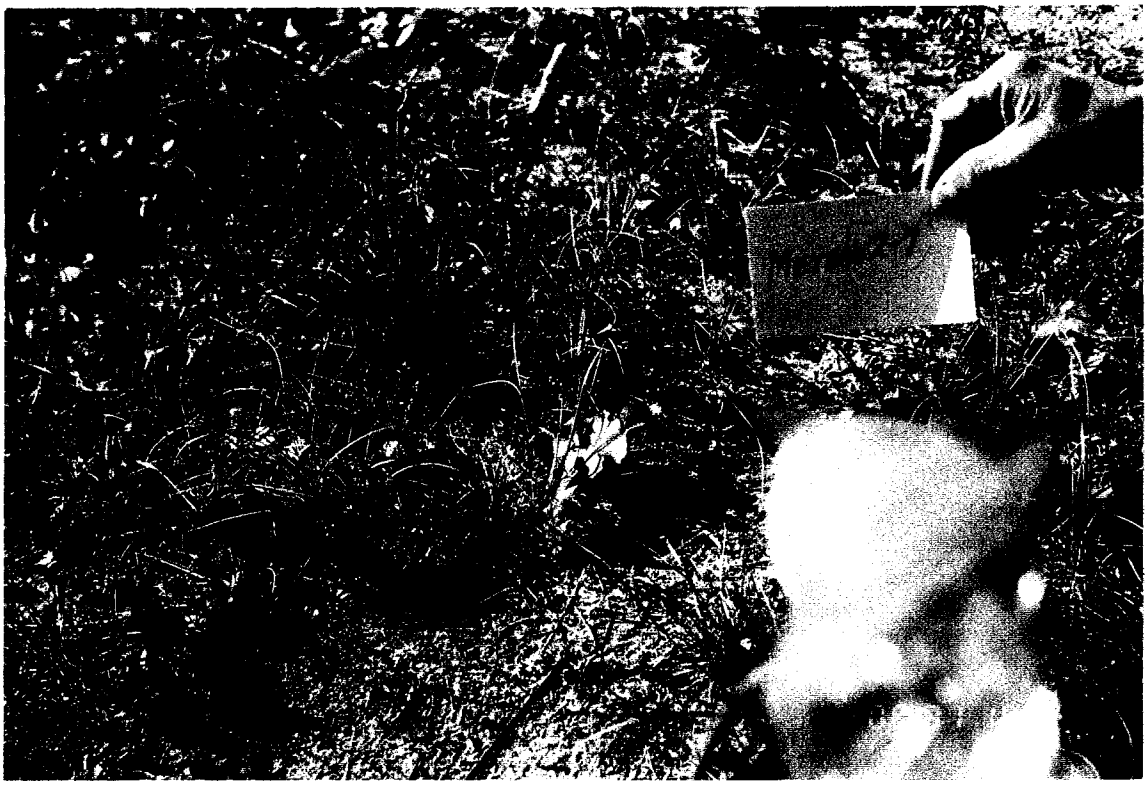


Figure B45. Staring radiometer Array D2, Channel 7

Figure B46. Staring radiometer Array D2, Channel 8

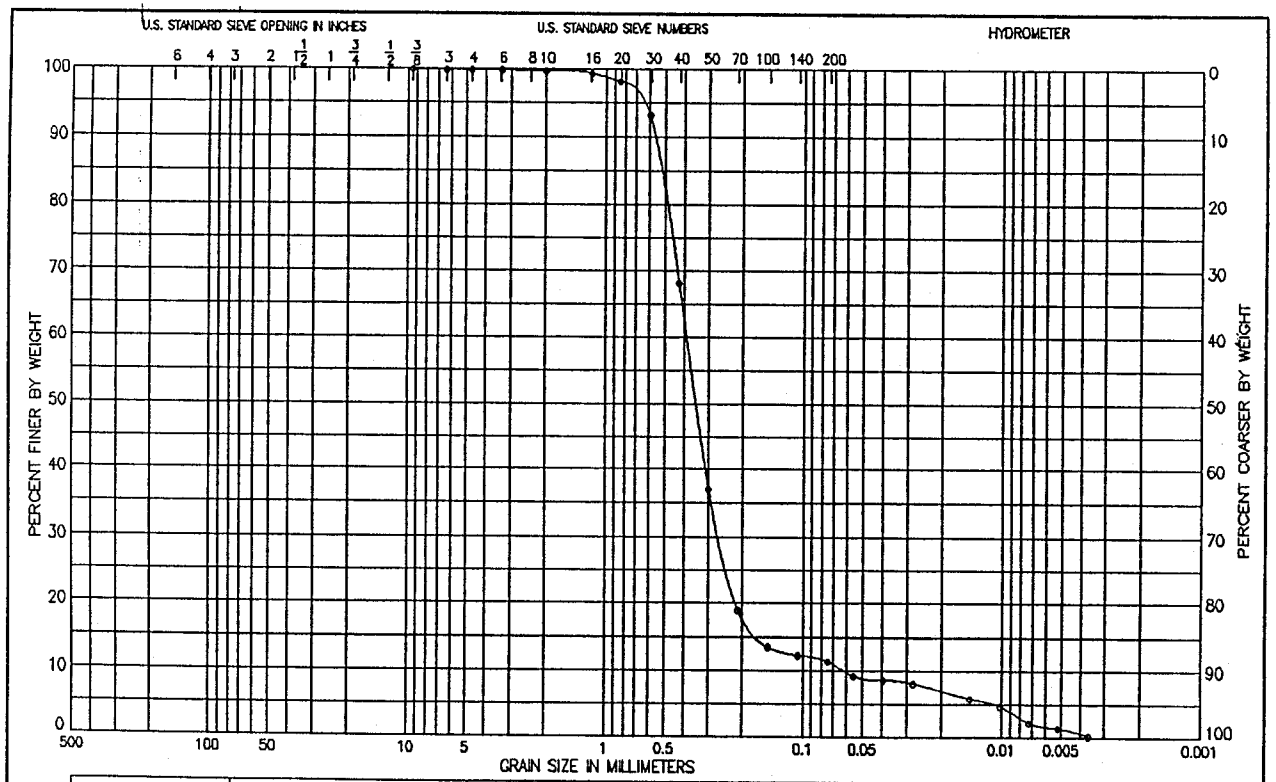
Appendix C
Soils Data

SOIL MOISTURE DATA
SITE C

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
15/09	1120	1	10	4.9	
15/09	1125	2	19	7.8	
16/09	1050	3	25	7.6	
16/09	1053	4	15	6.1	
17/09	1139	5	14	10.7	
17/09	1142	6	32	21.1	
18/09	1439	7	12	9.0	
18/09	1443	8	38	19.3	
19/09	1128	9	36	10.4	
19/09	1130	10	20	18.1	
20/09	1228	11	40	15.8	
20/09	1232	12	14	13.8	
21/09	1029	13	39	15.5	
21/09	1033	14	32	21.0	
22/09	1220	15	18	17.4	
22/09	1224	16	24	12.3	
23/09	1223	17	40	17.3	
23/09	1226	18	40	20.9	
24/09	1428	19	40	13.1	
24/09	1433	20	40	24.2	
25/09	1423	21	40	13.7	
25/09	1430	22	40	10.1	
26/09	1141	23	40	12.4	
26/09	1144	24	40	13.6	
27/09	1413	25	40	23.9	
27/09	1418	26	40	26.7	
28/09	1340	27	40	16.4	
28/09	1342	28	40	22.5	
29/09	1142	29	34	18.1	
29/09	1145	30	17	14.5	
30/09	1205	31	40	15.6	
30/09	1208	32	36	10.3	
01/10	1242	33	27	10.6	
01/10	1245	34	9	8.2	
02/10	1233	35	11	9.0	
02/10	1237	36	9	8.6	
03/10	1137	37	23	11.9	
03/10	1141	38	17	9.0	
04/10	1028	39	35	15.2	
04/10	1031	40	4	11.7	
05/10	1130	41	32	11.0	
05/10	1135	42	35	14.0	
06/10	832	43	14	10.1	
06/10	837	44	16	8.1	

SOIL MOISTURE DATA
SITE C

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1122	45	23	12.6	
07/10	1126	46	11	6.9	
08/10	840	47	40	13.1	
08/10	844	48	32	24.5	
09/10	1129	49	34	11.4	
09/10	1131	50	34	39.6	
10/10	1145	51	32	16.3	
10/10	1147	52	20	13.6	
11/10	1125	53	30	16.0	
11/10	1128	54	16	12.7	
12/10	938	55	40	22.6	
12/10	941	56	40	18.8	
13/10	1144	57	33	18.6	
13/10	1147	58	20	14.9	
14/10	1336	59	40	17.3	
14/10	1338	60	40	12.5	
15/10	1058	61	19	15.6	
15/10	1100	62	20	15.6	
16/10	1053	63	18	14.5	
16/10	1055	64	40	29.6	
17/10	1124	65	32	25.0	
17/10	1126	66	24	18.2	
18/10	1040	67	28	0.0	NO TROXLER
18/10	1044	68	32	0.0	NO TROXLER
19/10	1105	69	40	0.0	NO TROXLER
19/10	1108	70	36	0.0	NO TROXLER
20/10	1517	71	26	0.0	NO TROXLER
20/10	1520	72	40	0.0	NO TROXLER
21/10	1625	73	36	0.0	NO TROXLER
21/10	1627	74	22	0.0	NO TROXLER
22/10	1157	75	16	0.0	NO TROXLER
22/10	1200	76	16	0.0	NO TROXLER
23/10	948	77	40	0.0	NO TROXLER
23/10	950	78	18	0.0	NO TROXLER
24/10	1140	79	18	0.0	NO TROXLER
24/10	1142	80	25	0.0	NO TROXLER
25/10	948	81	32	0.0	NO TROXLER
25/10	950	82	40	0.0	NO TROXLER
25/10	952	83	40	0.0	DUFF
25/10	954	84	16	0.0	LOAM



LL	PL	PI	GS	NAT W,%	ORG,%
NP			2.68 EST		

CLASSIFICATION
SILTY SAND (SP-SM), DARK GRAY

GRADATION CURVE | LABORATORY USAE WES – STF/GL

PROJECT SWOE CHARACTERIZATION STUDY
GRAYLING, MI
BORING NO. SITE C SAMPLE NO.
DEPTH/ELEV DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE C SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

NON-PLASTIC GS: 2.68 est WC: .00
CLASSIFICATION: 108
SILTY SAND (SP-SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: 1412.0 gms.
PARTIAL WEIGHT AFTER SPLIT: 56.6 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	3/8 in	9.500	100.0	.0
1.0	No 3	6.350	99.9	.1
.2	No 4	4.750	99.9	.1
.2	No 6	3.350	99.9	.1
1.3	No 10	2.000	99.8	.2
.2	No 16	1.180	99.5	.5
.9	No 20	.850	98.2	1.8
3.7	No 30	.600	93.3	6.7
17.9	No 40	.425	68.2	31.8
35.6	No 50	.300	37.0	63.0
45.9	No 70	.212	18.9	81.1
48.9	No 100	.150	13.6	86.4
49.6	No 140	.106	12.3	87.7
50.1	No 200	.075	11.5	88.5
HYDROMETER:				
RDGS	TEMP			
3.5	21.5	.0557	9.3	90.7
3.3	21.5	.0395	8.7	91.3
3.1	21.5	.0279	8.2	91.8
2.3	21.5	.0145	5.9	94.1
2.0	21.0	.0103	4.8	95.2
1.0	21.5	.0073	2.3	97.7
.7	21.5	.0052	1.4	98.6
.2	22.0	.0036	.3	99.7

PERCENT GRAVEL = .1
PERCENT SAND = 88.5
PERCENT FINES = 11.5

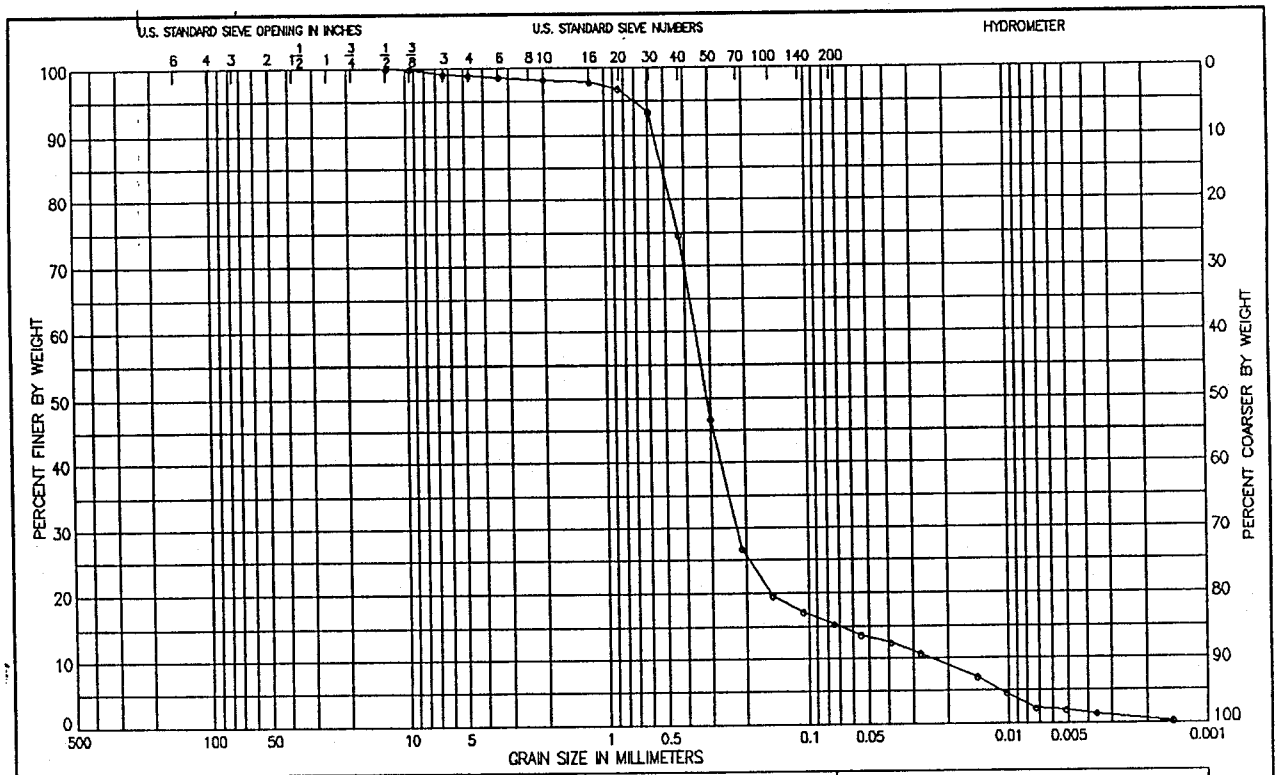
D60 = .39
D30 = .27
D10 = .02
CU = 16.61
CC = 7.65

SOIL MOISTURE DATA
SITE D

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
15/09	1151	1	8	4.4	
15/09	1154	2	8	8.2	
16/09	1135	3	13	8.7	
16/09	1138	4	13	8.8	
17/09	1321	5	12	12.8	
17/09	1325	6	12	9.6	
18/09	1404	7	25	18.5	
18/09	1407	8	14	15.2	
19/09	1214	9	16	12.7	
19/09	1216	10	10	10.6	
20/09	1148	11	12	11.4	
20/09	1150	12	8	9.0	
21/09	1116	13	14	10.1	
21/09	1120	14	11	9.8	
22/09	1303	15	14	13.4	
22/09	1305	16	10	8.9	
23/09	1301	17	8	9.3	
23/09	1303	18	8	7.2	
24/09	1520	19	9	7.6	
24/09	1525	20	10	10.4	
25/09	1506	21	2	6.7	
25/09	1508	22	3	7.1	
26/09	1224	23	7	7.1	
26/09	1227	24	5	7.3	
27/09	1500	25	14	11.4	
27/09	1503	26	16	14.8	
28/09	1422	27	14	10.7	
28/09	1425	28	11	7.8	
29/09	1155	29	10	17.0	
29/09	1158	30	7	18.6	
30/09	1305	31	6	9.2	
30/09	1313	32	8	13.2	
01/10	1328	33	26	15.0	
01/10	1331	34	13	7.3	
02/10	1310	35	4	4.7	
02/10	1314	36	6	7.2	
03/10	1211	37	4	6.2	
03/10	1214	38	9	10.1	
04/10	1102	39	2	6.6	
04/10	1106	40	3	9.4	
05/10	1214	41	3	11.9	
05/10	1217	42	1	3.9	
06/10	910	43	2	7.3	
06/10	910	44	3	9.0	

SOIL MOISTURE DATA
SITE D

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1215	45	1	7.9	
07/10	1218	46	1	6.9	
08/10	920	47	3	6.2	
08/10	925	48	2	9.6	
09/10	1211	49	11	10.1	
09/10	1214	50	13	14.4	
10/10	1212	51	12	10.2	
10/10	1215	52	13	11.8	
11/10	1157	53	9	10.2	
11/10	1200	54	14	11.2	
12/10	1141	55	12	10.0	
12/10	1144	56	15	12.1	
13/10	1053	57	15	12.0	
13/10	1055	58	12	10.5	
14/10	1411	59	14	10.1	
14/10	1414	60	12	8.7	
15/10	1024	61	12	15.4	
15/10	1026	62	11	13.1	
16/10	1144	63	13	12.5	
16/10	1146	64	15	15.9	
17/10	1158	65	14	14.6	
17/10	1201	66	13	14.1	
18/10	939	67	7	0.0	NO TROXLER
18/10	942	68	8	0.0	NO TROXLER
19/10	1138	69	13	0.0	NO TROXLER
19/10	1142	70	32	0.0	NO TROXLER
20/10	1550	71	20	0.0	NO TROXLER
20/10	1554	72	16	0.0	NO TROXLER
21/10	1653	73	8	0.0	NO TROXLER
21/10	1656	74	8	0.0	NO TROXLER
22/10	1225	75	17	0.0	NO TROXLER
22/10	1228	76	20	0.0	NO TROXLER
23/10	1010	77	20	0.0	NO TROXLER
23/10	1013	78	15	0.0	NO TROXLER
24/10	1206	79	13	0.0	NO TROXLER
24/10	1209	80	14	0.0	NO TROXLER
25/10	1015	81	12	0.0	NO TROXLER
25/10	1018	82	5	0.0	NO TROXLER



LL	PL	PI	GS	NAT W,%	ORG,%
34	28	6	2.69 EST		

CLASSIFICATION
SILTY SAND (SM), DARK GRAY

GRADATION CURVE | LABORATORY USAE WES – STF/GL

PROJECT SWOE CHARACTERIZATION STUDY
· GRAYLING, MI
BORING NO. SITE D SAMPLE NO.
DEPTH/ELEV DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE D SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

LL: 34 PL: 28 PI: 6 GS: 2.69 est WC: .00
CLASSIFICATION: 160
SILTY SAND (SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: 1494.0 gms.
PARTIAL WEIGHT AFTER SPLIT: 55.2 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	1/2 in	12.500	100.0	.0
1.5	3/8 in	9.500	99.9	.1
11.3	No 3	6.350	99.1	.9
2.9	No 4	4.750	98.9	1.1
5.0	No 6	3.350	98.6	1.4
6.0	No 10	2.000	98.2	1.8
.2	No 16	1.180	97.9	2.1
.8	No 20	.850	96.8	3.2
2.7	No 30	.600	93.4	6.6
13.3	No 40	.425	74.5	25.5
29.0	No 50	.300	46.6	53.4
40.2	No 70	.212	26.7	73.3
44.2	No 100	.150	19.6	80.4
45.6	No 140	.106	17.1	82.9
46.6	No 200	.075	15.3	84.7
HYDROMETER:				
RDGS	TEMP			
5.0	21.5	.0549	13.6	86.4
4.6	21.5	.0389	12.5	87.5
4.0	21.5	.0277	10.8	89.2
2.7	21.5	.0144	7.1	92.9
1.9	21.0	.0103	4.5	95.5
1.0	21.5	.0073	2.3	97.7
.9	21.5	.0052	2.0	98.0
.6	22.0	.0036	1.4	98.6
.4	21.0	.0015	.3	99.7

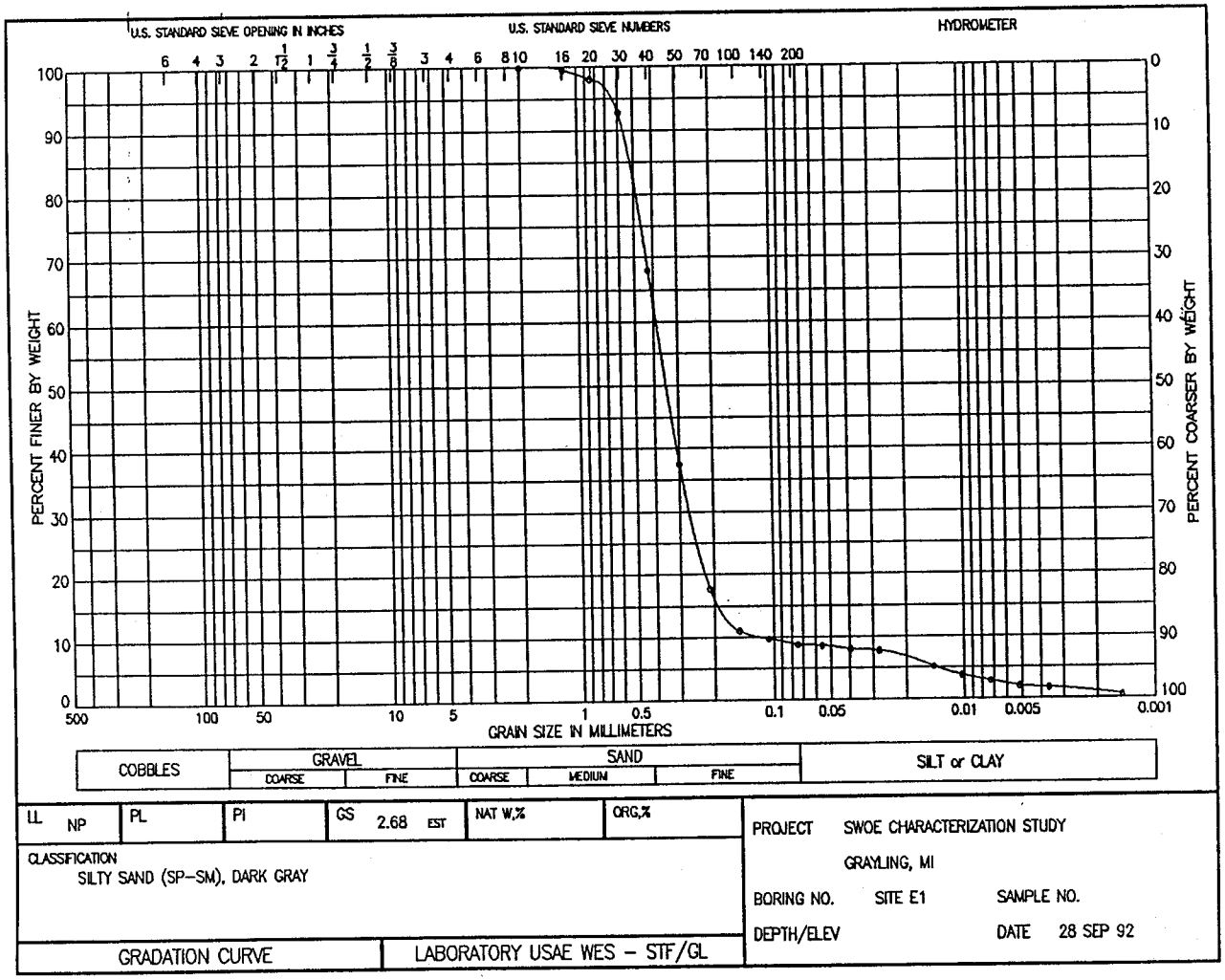
PERCENT GRAVEL = 1.1
PERCENT SAND = 83.6
PERCENT FINES = 15.3

SOIL MOISTURE DATA
SITE E1

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER COMMENTS (%)
15/09	1026	1	12	7.8
15/09	1029	2	8	6.5
16/09	1020	3	14	10.7
16/09	1028	4	14	8.6
17/09	1114	5	22	11.6
17/09	1117	6	21	17.0
18/09	1417	7	14	14.2
18/09	1420	8	14	11.1
19/09	1107	9	14	13.3
19/09	1110	10	13	11.4
20/09	1242	11	10	10.1
20/09	1244	12	4	7.2
21/09	1009	13	12	12.0
21/09	1011	14	9	8.9
22/09	1156	15	6	8.8
22/09	1159	16	6	10.1
23/09	1204	17	9	8.0
23/09	1206	18	4	9.2
24/04	1407	19	4	5.9
24/09	1410	20	6	7.4
25/09	1406	21	6	6.7
25/09	1408	22	11	9.9
26/09	1116	23	9	7.4
26/09	1119	24	4	7.0
27/09	1354	25	11	11.7
27/09	1357	26	11	15.3
28/09	1315	27	14	11.6
28/09	1320	28	12	14.4
29/09	1120	29	16	12.3
29/09	1123	30	15	9.4
30/09	1120	31	10	7.5
30/09	1123	32	9	8.3
01/10	1034	33	5	9.4
01/10	1036	34	10	6.3
02/10	1211	35	4	5.1
02/10	1214	36	2	6.8
03/10	1115	37	3	6.8
03/10	1118	38	2	11.2
04/10	1007	39	7	7.0
04/10	1011	40	2	9.6
05/10	1115	41	3	6.9
05/10	1118	42	7	6.9
06/10	815	43	6	6.4
06/10	818	44	3	3.9

SOIL MOISTURE DATA
SITE E1

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1122	45	1	8.3	
07/10	1125	46	0	3.7	
08/10	822	47	1	5.9	
08/10	826	48	2	3.5	
09/10	1117	49	8	11.3	
09/10	1121	50	10	11.0	
10/10	1125	51	8	8.0	
10/10	1128	52	14	10.4	
11/10	1100	53	14	8.6	
11/10	1103	54	17	15.4	
12/10	923	55	6	8.4	
12/10	925	56	14	12.5	
13/10	1155	57	14	8.3	
13/10	1158	58	14	11.3	
14/10	1314	59	16	10.8	
14/10	1316	60	11	6.0	
15/10	1343	61	18	11.2	
15/10	1345	62	28	16.2	
16/10	1015	63	16	14.2	
16/10	1019	64	22	18.0	
17/10	1100	65	12	9.5	
17/10	1103	66	12	11.9	
18/10	1108	67	12	12.6	
18/10	1111	68	6	7.9	
19/10	1052	69	9	0.0	NO TROXLER
19/10	1055	70	20	0.0	NO TROXLER
20/10	1458	71	21	0.0	NO TROXLER
20/10	1502	72	9	0.0	NO TROXLER
21/10	1610	73	9	0.0	NO TROXLER
21/10	1612	74	10	0.0	NO TROXLER
22/10	1145	75	18	0.0	NO TROXLER
22/10	1147	76	17	0.0	NO TROXLER
23/10	935	77	8	0.0	NO TROXLER
23/10	938	78	12	0.0	NO TROXLER
24/10	1125	79	11	0.0	NO TROXLER
24/10	1128	80	13	0.0	NO TROXLER
25/10	938	81	6	0.0	NO TROXLER
25/10	933	82	8	0.0	NO TROXLER
25/10	934	83	10	0.0	SAND
25/10	935	84	10	0.0	GRASS
25/10	936	85	16	0.0	MOSS



LL	PL	PI	GS	NAT W,%	ORG,%
NP			2.68 EST		

CLASSIFICATION
SILTY SAND (SP–SM), DARK GRAY

GRADATION CURVE | LABORATORY USAE WES – STF/GL

PROJECT SWOE CHARACTERIZATION STUDY
GRAYLING, MI
BORING NO. SITE E1 SAMPLE NO.
DEPTH/ELEV DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE E1 SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

NON-PLASTIC GS: 2.68 est WC: .00
CLASSIFICATION: 126
SILTY SAND (SP-SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: .0 gms.
PARTIAL WEIGHT AFTER SPLIT: 54.9 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 10	2.000	100.0	.0
.2	No 16	1.180	99.6	.4
1.0	No 20	.850	98.2	1.8
3.9	No 30	.600	92.9	7.1
17.5	No 40	.425	68.1	31.9
34.3	No 50	.300	37.5	62.5
45.2	No 70	.212	17.7	82.3
48.8	No 100	.150	11.1	88.9
49.5	No 140	.106	9.8	90.2
50.0	No 200	.075	8.9	91.1
HYDROMETER:				
RDGS	TEMP			
3.2	21.5	.0558	8.7	91.3
3.0	21.5	.0396	8.1	91.9
2.9	21.5	.0280	7.8	92.2
2.0	21.5	.0146	5.2	94.8
1.6	21.0	.0103	3.8	96.2
1.2	21.5	.0073	2.9	97.1
.9	21.5	.0052	2.0	98.0
.7	22.0	.0036	1.7	98.3
.5	21.0	.0015	.6	99.4

PERCENT GRAVEL = .0
PERCENT SAND = 91.1
PERCENT FINES = 8.9

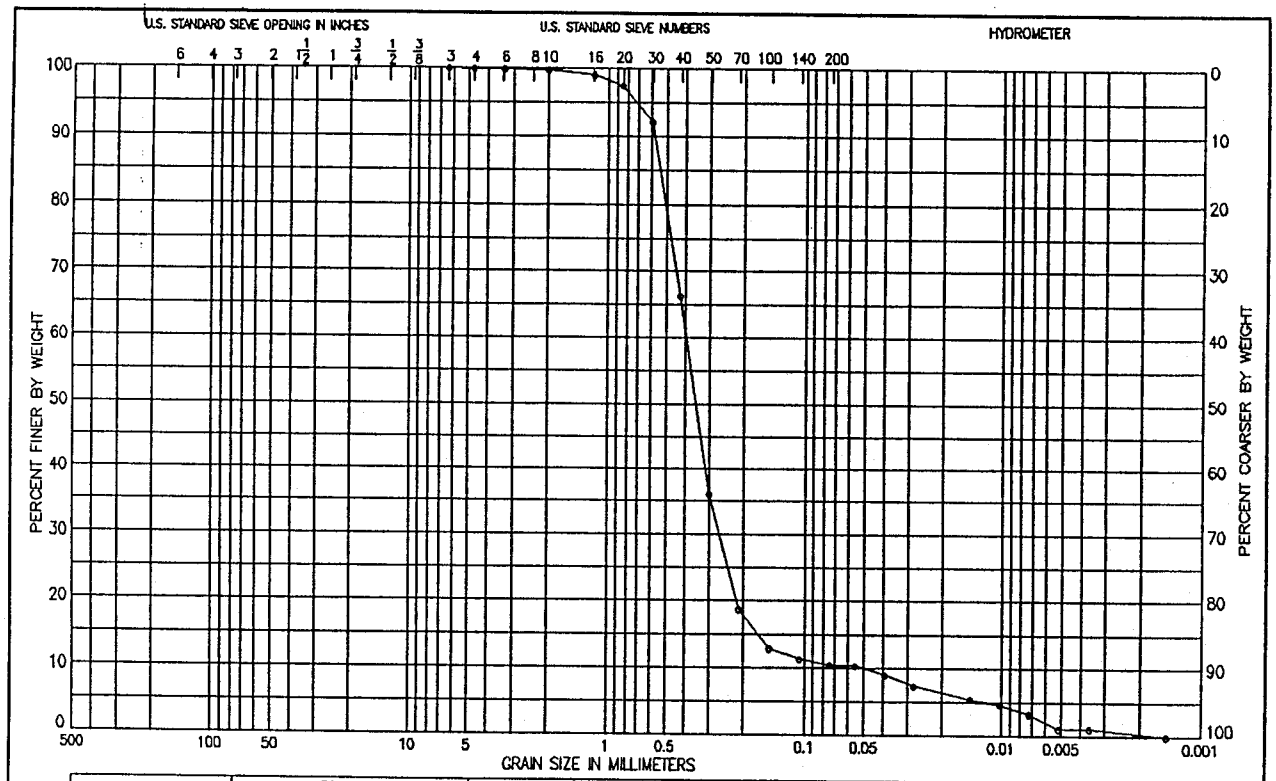
D60 = .39
D30 = .27
D10 = .11
CU = 3.51
CC = 1.63

SOIL MOISTURE DATA
SITE E2

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
15/09	1014	1	10	5.9	
15/09	1019	2	10	7.5	
16/09	1008	3	13	8.5	
16/09	1012	4	14	10.5	
17/09	1124	5	19	19.0	
17/09	1130	6	15	14.1	
18/09	1421	7	28	18.5	
18/09	1430	8	25	17.2	
19/09	1116	9	16	14.4	
19/09	1120	10	18	10.9	
20/09	1249	11	19	12.8	
20/09	1252	12	10	9.1	
21/09	1016	13	22	13.3	
21/09	1019	14	22	14.8	
22/09	1208	15	26	15.8	
22/09	1211	16	24	13.0	
23/09	1211	17	13	7.4	
23/09	1214	18	19	12.7	
24/09	1413	19	9	8.4	
24/09	1417	20	30	14.9	
25/09	1415	21	16	11.9	
25/09	1418	22	16	11.2	
26/09	1121	23	14	9.4	
26/09	1128	24	18	13.3	
27/09	1403	25	21	15.4	
27/09	1405	26	25	15.4	
28/09	1327	27	20	12.0	
28/09	1330	28	15	14.4	
29/09	1128	29	14	11.8	
29/09	1131	30	15	10.3	
30/09	1150	31	18	11.8	
30/09	1153	32	18	13.5	
01/10	1235	33	22	13.2	
01/10	1238	34	24	13.7	
02/10	1215	35	11	9.0	
02/10	1218	36	9	8.6	
03/10	1123	37	23	11.9	
03/10	1126	38	17	9.0	
04/10	1016	39	26	15.7	
04/10	1020	40	12	10.0	
05/10	1124	41	2	8.5	
05/10	1127	42	14	16.7	
06/10	820	43	14	11.2	
06/10	824	44	13	7.7	

SOIL MOISTURE DATA
SITE E2

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1130	45	10	6.8	
07/10	1134	46	11	8.1	
08/10	829	47	10	9.3	
08/10	833	48	8	7.6	
09/10	1123	49	16	12.2	
09/10	1127	50	29	15.5	
10/10	1131	51	20	11.1	
10/10	1133	52	21	14.0	
11/10	1112	53	26	15.1	
11/10	1115	54	20	11.1	
12/10	928	55	20	17.4	
12/10	931	56	13	11.6	
13/10	1203	57	20	13.6	
13/10	1205	58	24	15.2	
14/10	1323	59	18	15.7	
14/10	1325	60	13	8.8	
15/10	1352	61	30	16.6	
15/10	1355	62	29	15.4	
16/10	1039	63	18	16.4	
16/10	1041	64	18	13.9	
17/10	1111	65	28	14.5	
17/10	1114	66	31	17.6	
18/10	1115	67	18	0.0	NO TROXLER
18/10	1119	68	10	0.0	NO TROXLER
19/10	1059	69	17	0.0	NO TROXLER
19/10	1103	70	24	0.0	NO TROXLER
20/10	1504	71	18	0.0	NO TROXLER
20/10	1507	72	22	0.0	NO TROXLER
21/10	1616	73	16	0.0	NO TROXLER
21/10	1619	74	21	0.0	NO TROXLER
22/10	1150	75	24	0.0	NO TROXLER
22/10	1153	76	26	0.0	NO TROXLER
23/10	941	77	15	0.0	NO TROXLER
23/10	944	78	31	0.0	NO TROXLER
24/10	1132	79	18	0.0	NO TROXLER
24/10	1135	80	30	0.0	NO TROXLER
25/10	940	81	17	0.0	NO TROXLER
25/10	942	82	28	0.0	NO TROXLER



LL	PL	PI	GS	NAT W,%	ORG,%
34	30	4	2.69 EST		

CLASSIFICATION
SILTY SAND (SP-SM), DARK GRAY

GRADATION CURVE | LABORATORY USAE WES – STF/GL

PROJECT SWOE CHARACTERIZATION STUDY
GRAYLING, MI
BORING NO. SITE E2 SAMPLE NO.
DEPTH/ELEV DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE E2 SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

LL: 34 PL: 30 PI: 4 GS: 2.69 est WC: .00
CLASSIFICATION: 142
SILTY SAND (SP-SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: 1435.0 gms.
PARTIAL WEIGHT AFTER SPLIT: 57.9 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 3	6.350	100.0	.0
.5	No 4	4.750	100.0	.0
.5	No 6	3.350	99.9	.1
2.1	No 10	2.000	99.8	.2
.4	No 16	1.180	99.1	.9
1.3	No 20	.850	97.5	2.5
4.4	No 30	.600	92.2	7.8
19.4	No 40	.425	66.4	33.6
37.0	No 50	.300	36.0	64.0
47.1	No 70	.212	18.6	81.4
50.4	No 100	.150	12.9	87.1
51.3	No 140	.106	11.4	88.6
51.8	No 200	.075	10.5	89.5

HYDROMETER:

RDGS	TEMP			
4.0	21.5	.0553	10.4	89.6
3.5	21.5	.0393	9.1	90.9
2.9	21.5	.0279	7.4	92.6
2.2	21.5	.0145	5.5	94.5
2.0	21.0	.0103	4.7	95.3
1.4	21.5	.0073	3.3	96.7
.6	21.5	.0052	1.1	98.9
.5	22.0	.0036	1.1	98.9
.3	21.0	.0015	.0	100.0

PERCENT GRAVEL = .0
PERCENT SAND = 89.5
PERCENT FINES = 10.5

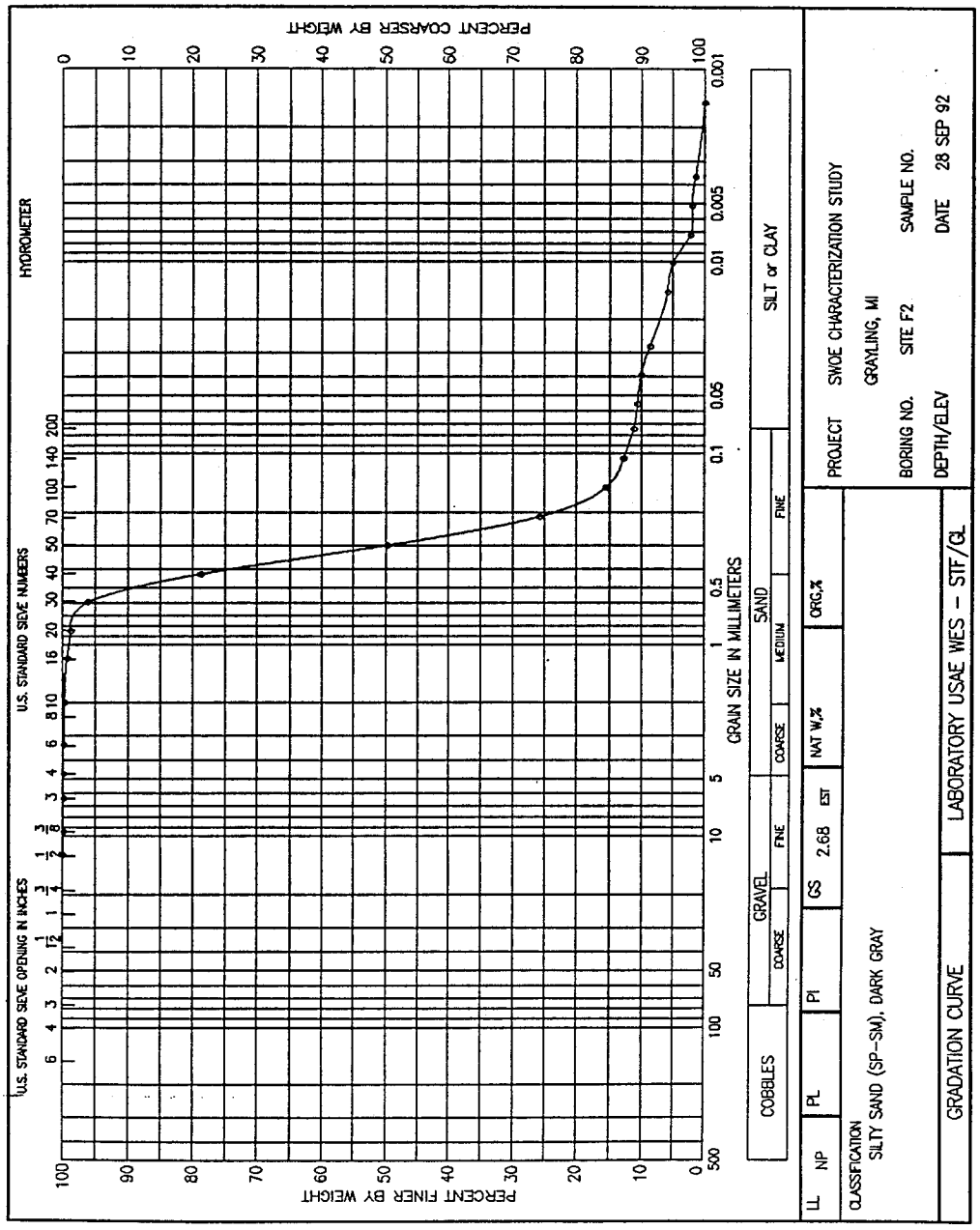
D60 = .40
D30 = .27
D10 = .06
CU = 7.05
CC = 3.22

SOIL MOISTURE DATA
SITE F

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
15/09	1138	1	10	4.6	
15/09	1142	2	10	4.4	
16/09	1120	3	17	6.7	
16/09	1124	4	14	6.7	
17/09	1308	5	21	16.6	
17/09	1312	6	21	15.3	
18/09	1506	7	19	16.0	
18/09	1509	8	18	14.3	
19/09	1158	9	22	21.6	
19/09	1201	10	16	17.1	
20/09	1204	11	18	15.8	
20/09	1206	12	16	12.2	
21/09	1059	13	19	15.4	
21/09	1103	14	24	15.5	
22/09	1253	15	16	13.4	
22/09	1255	16	20	14.1	
23/09	1248	17	14	13.3	
23/09	1252	18	13	11.0	
24/09	1502	19	6	8.1	
24/09	1502	20	10	7.9	
25/09	1455	21	22	10.3	
25/09	1458	22	26	14.6	
26/09	1213	23	12	8.3	
26/09	1216	24	10	8.1	
27/09	1450	25	40	23.8	
27/09	1453	26	39	19.0	
28/09	1410	27	11	7.3	
28/09	1413	28	26	16.9	
29/09	1208	29	20	11.7	
29/09	1211	30	19	17.3	
30/09	1240	31	16	14.7	
30/09	1245	32	22	15.7	
01/10	1308	33	18	12.1	
01/10	1308	34	7	9.9	
02/10	1253	35	6	7.7	
02/10	1255	36	16	13.1	
03/10	1158	37	5	6.3	
03/10	1205	38	9	9.9	
04/10	1054	39	10	8.9	
04/10	1057	40	19	11.4	
05/10	1205	41	5	8.9	
05/10	1210	42	8	7.6	
06/10	858	43	26	16.7	
06/10	902	44	3	5.9	

SOIL MOISTURE DATA
SITE F

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1203	45	7	9.3	
07/10	1207	46	3	7.1	
08/10	906	47	2	7.4	
08/10	910	48	6	8.4	
09/10	1202	49	19	19.4	
09/10	1205	50	16	14.4	
10/10	1206	51	16	4.9	
10/10	1206	52	12	15.1	
11/10	1147	53	6	16.5	
11/10	1150	54	20	19.2	
12/10	1154	55	21	16.3	
12/10	1157	56	22	14.5	
13/10	1104	57	18	15.2	
13/10	1108	58	23	12.8	
14/10	1359	59	23	11.3	
14/10	1403	60	20	12.1	
15/10	1034	61	14	15.3	
15/10	1037	62	14	13.6	
16/10	1134	63	13	13.0	
16/10	1136	64	22	17.2	
17/10	1146	65	16	15.2	
17/10	1148	66	21	19.9	
18/10	958	67	10	0.0	NO TROXLER
18/10	1002	68	40	0.0	NO TROXLER
19/10	1128	69	30	0.0	NO TROXLER
19/10	1131	70	20	0.0	NO TROXLER
20/10	1518	71	16	0.0	NO TROXLER
20/10	1520	72	15	0.0	NO TROXLER
21/10	1643	73	24	0.0	NO TROXLER
21/10	1646	74	27	0.0	NO TROXLER
22/10	1215	75	23	0.0	NO TROXLER
22/10	1218	76	21	0.0	NO TROXLER
23/10	1003	77	25	0.0	NO TROXLER
23/10	1005	78	24	0.0	NO TROXLER
24/10	1159	79	18	0.0	NO TROXLER
24/10	1202	80	18	0.0	NO TROXLER
25/10	1007	81	17	0.0	NO TROXLER
25/10	1010	82	18	0.0	NO TROXLER


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT or CLAY
LL NP
PL
PI
GS 2.68 EST
NAT W,%
ORG,%
CLASSIFICATION
SILTY SAND (SP-SM), DARK GRAY
GRADATION CURVE
LABORATORY USAE WES - STF/GL
PROJECT SWOE CHARACTERIZATION STUDY
GRAYLING, MI
BORING NO. SITE F2
SAMPLE NO.
DEPTH/ELEV
DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE F2 SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

NON-PLASTIC GS: 2.68 est WC: .00
CLASSIFICATION: 178
SILTY SAND (SP-SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: 2328.0 gms.
PARTIAL WEIGHT AFTER SPLIT: 56.5 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	1/2 in	12.500	100.0	.0
2.6	3/8 in	9.500	99.9	.1
.0	No 3	6.350	99.9	.1
.1	No 4	4.750	99.9	.1
.4	No 6	3.350	99.9	.1
3.0	No 10	2.000	99.7	.3
.2	No 16	1.180	99.4	.6
.5	No 20	.850	98.9	1.1
2.0	No 30	.600	96.2	3.8
11.9	No 40	.425	78.7	21.3
28.3	No 50	.300	49.8	50.2
41.9	No 70	.212	25.8	74.2
47.7	No 100	.150	15.5	84.5
49.2	No 140	.106	12.9	87.1
50.1	No 200	.075	11.3	88.7
HYDROMETER:				
RDGS	TEMP			
4.0	21.5	.0555	10.7	89.3
3.8	21.5	.0393	10.1	89.9
3.3	21.5	.0279	8.7	91.3
2.3	21.5	.0145	5.9	94.1
2.1	21.0	.0103	5.1	94.9
1.0	21.5	.0073	2.3	97.7
.9	21.5	.0052	2.0	98.0
.6	22.0	.0036	1.4	98.6
.3	21.0	.0015	.0	100.0

PERCENT GRAVEL = .1
PERCENT SAND = 88.6
PERCENT FINES = 11.3

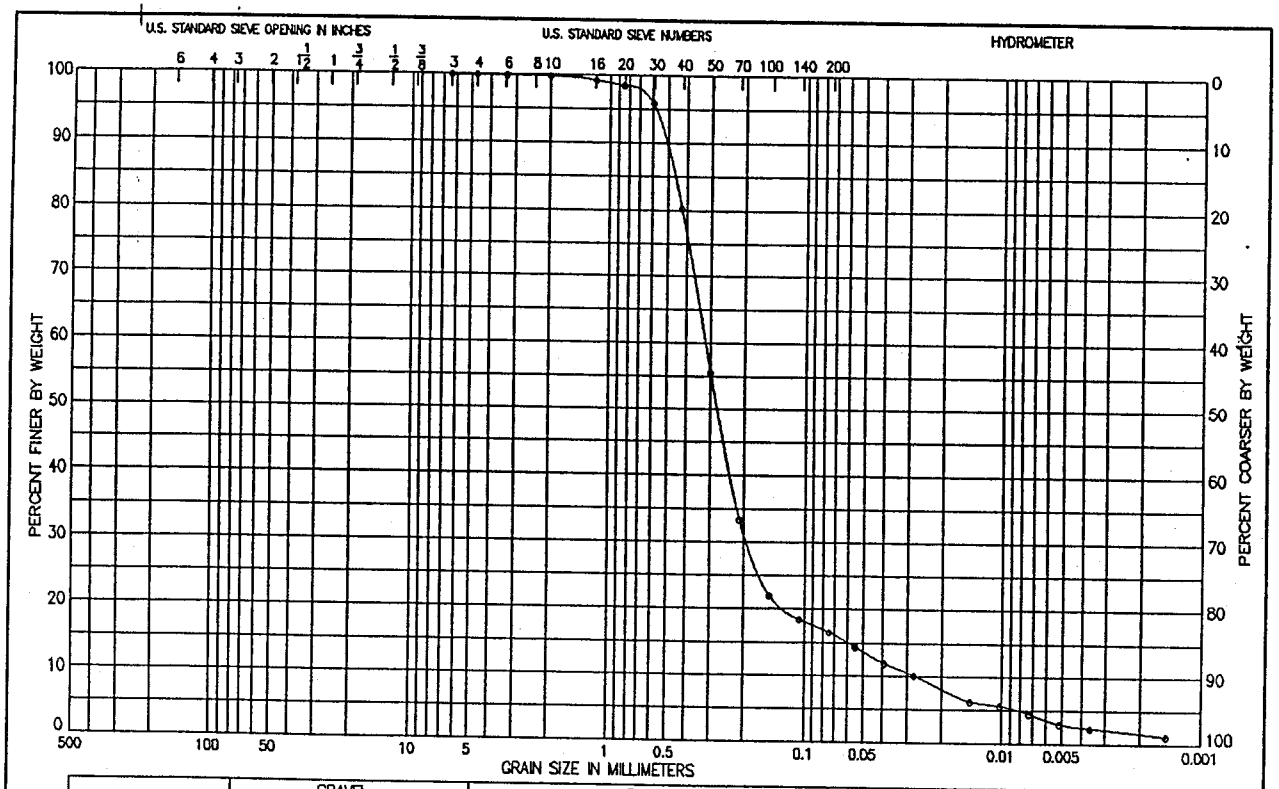
D60 = .34
D30 = .23
D10 = .05
CU = 6.93
CC = 3.03

SOIL MOISTURE DATA
SITE G

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
15/09	1102	1	16	9.2	
15/09	1105	2	16	6.9	
16/09	1118	3	30	8.1	
16/09	1110	4	19	6.6	
17/09	1254	5	40	18.1	
17/09	1258	6	40	20.5	
18/09	1455	7	40	23.2	
18/09	1458	8	40	29.8	
19/09	1145	9	40	17.9	
19/09	1148	10	40	21.3	
20/09	1214	11	40	18.5	
20/09	1218	12	30	12.1	
21/09	1045	13	40	26.5	
21/09	1048	14	40	22.0	
22/09	1236	15	40	23.5	
22/09	1240	16	30	15.7	
23/09	1237	17	32	14.0	
23/09	1239	18	40	17.6	
24/09	1445	19	40	13.6	
24/09	1449	20	40	15.1	
25/09	1443	21	40	12.5	
25/09	1446	22	40	12.6	
26/09	1200	23	40	13.3	
26/09	1203	24	40	14.0	
27/09	1430	25	40	20.0	
27/09	1435	26	40	24.4	
28/09	1350	27	40	18.7	
28/09	1354	28	40	21.5	
29/09	1155	29	26	17.0	
29/09	1158	30	32	18.6	
30/09	1222	31	40	17.0	
30/09	1225	32	40	18.1	
01/10	1300	33	40	14.7	
01/10	1304	34	30	23.2	
02/10	1253	35	6	7.7	
02/10	1255	36	16	13.1	
03/10	1158	37	5	6.3	
03/10	1205	38	9	9.9	
04/10	1037	39	34	12.6	
04/10	1040	40	36	12.8	
05/10	1144	41	38	24.0	
05/10	1147	42	34	15.0	
06/10	847	43	33	10.9	
06/10	852	44	35	11.6	

SOIL MOISTURE DATA
SITE G

DATE	TIME	SAMPLE NUMBER	SPEEDY MOISTURE GAUGE (%)	TROXLER (%)	COMMENTS
07/10	1151	45	15	10.5	
07/10	1156	46	32	12.6	
08/10	854	47	21	11.8	
08/10	857	48	29	14.5	
09/10	1146	49	39	21.6	
09/10	1150	50	20	19.4	
10/10	1155	51	28	16.4	
10/10	1159	52	29	18.4	
11/10	1135	53	40	20.1	
11/10	1137	54	40	20.2	
12/10	951	55	30	19.1	
12/10	954	56	26	15.6	
13/10	1121	57	34	15.7	
13/10	1124	58	40	20.7	
14/10	1348	59	40	18.1	
14/10	1351	60	40	20.7	
15/10	1044	61	34	19.2	
15/10	1047	62	33	18.6	
16/10	1125	63	32	18.2	
16/10	1127	64	40	35.8	
17/10	1135	65	40	32.7	
17/10	1138	66	32	26.9	
18/10	1018	67	32	0.0	NO TROXLER
18/10	1020	68	12	0.0	NO TROXLER
19/10	1118	69	40	0.0	NO TROXLER
19/10	1121	70	36	0.0	NO TROXLER
20/10	1528	71	24	0.0	NO TROXLER
20/10	1531	72	31	0.0	NO TROXLER
21/10	1634	73	40	0.0	NO TROXLER
21/10	1637	74	27	0.0	NO TROXLER
22/10	1208	75	40	0.0	NO TROXLER
22/10	1210	76	30	0.0	NO TROXLER
23/10	955	77	34	0.0	NO TROXLER
23/10	959	78	38	0.0	NO TROXLER
24/10	1150	79	40	0.0	NO TROXLER
24/10	1153	80	20	0.0	NO TROXLER
25/10	1000	81	26	0.0	NO TROXLER
25/10	1003	82	36	0.0	NO TROXLER



LL	PL	PI	GS	NAT W,%	ORG,%
NP			2.68 EST		

CLASSIFICATION
SILTY SAND (SM), DARK GRAY

GRADATION CURVE | LABORATORY USAE WES – STF/GL

PROJECT SWOE CHARACTERIZATION STUDY
GRAYLING, MI
BORING NO. SITE G SAMPLE NO.
DEPTH/ELEV DATE 28 SEP 92

SIEVE ANALYSIS

PROJECT: SWOE CHARACTERIZATION STUDY
GRAYLING, MI

BORING: SITE G SAMPLE: DF: MD0193 .DAT
DEPTH: DATE: 28 SEP 92

NON-PLASTIC GS: 2.68 est WC: .00
CLASSIFICATION: 196
SILTY SAND (SM), DARK GRAY

TOTAL WEIGHT OF SAMPLE: 933.3 gms.
PARTIAL WEIGHT AFTER SPLIT: 53.2 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 3	6.350	100.0	.0
.2	No 4	4.750	100.0	.0
.2	No 6	3.350	100.0	.0
.9	No 10	2.000	99.9	.1
.3	No 16	1.180	99.3	.7
.7	No 20	.850	98.5	1.5
2.1	No 30	.600	95.9	4.1
10.4	No 40	.425	80.3	19.7
23.6	No 50	.300	55.6	44.4
35.4	No 70	.212	33.4	66.6
41.5	No 100	.150	22.0	78.0
43.4	No 140	.106	18.4	81.6
44.4	No 200	.075	16.5	83.5
HYDROMETER:				
RDGS	TEMP			
5.0	21.5	.0551	14.4	85.6
4.2	21.5	.0392	12.0	88.0
3.6	21.5	.0278	10.2	89.8
2.3	21.5	.0145	6.3	93.7
2.1	21.5	.0103	5.7	94.3
1.7	21.5	.0073	4.5	95.5
1.2	21.5	.0052	3.0	97.0
.9	22.0	.0036	2.4	97.6
.7	21.0	.0015	1.2	98.8

PERCENT GRAVEL = .0
PERCENT SAND = 83.5
PERCENT FINES = 16.5

Appendix D
Survey Data

GPS Surveyed Positions

EASTING	NORTHING	ELEVATION	POINT NAME
687084.60	4951890.36	365.04	ASL-BOOM
698902.11	4955523.52	429.36	BALD HILL
687596.48	4952028.03	368.26	C-NC
687659.76	4951943.16	367.26	C-NE
687641.99	4951977.90	369.66	C-NN
687612.57	4952035.57	369.34	C-NW
687644.45	4951935.84	368.42	C-SC
687629.38	4951926.78	368.56	C-SE-NOGAS
687611.28	4951962.04	367.58	C-SS
687580.69	4952019.49	366.89	C-SW
687352.28	4952504.47	368.81	D-NC
687430.01	4952391.06	354.50	D-NE
687365.20	4952511.22	368.80	D-NW
687414.56	4952383.26	355.29	D-SC
687398.57	4952375.32	355.93	D-SE
687336.23	4952495.93	368.33	D-SW
687244.62	4951960.50	354.56	E-CEN
687308.91	4952002.43	354.18	E-NE
687193.35	4951906.43	354.42	E-SC
687205.66	4951894.80	354.36	E-SE
687180.84	4951918.58	354.68	E-SW
687226.63	4951933.84	354.65	E-TREE
687976.86	4952725.29	376.00	F-NC
687966.21	4952737.40	376.93	F-NW
687875.08	4952618.37	359.42	F-SC
687885.71	4952608.31	361.69	F-SE
687862.51	4952630.25	359.10	F-SW
687508.82	4952196.69	355.27	FL-E
687522.95	4952251.58	354.79	FL-NN
687475.57	4952201.27	354.51	FL-SS

687482.37	4952249.43	354.92	FL-WW
687495.78	4952222.85	354.38	FL-X
690786.99	4955233.28	362.51	FRED
690630.71	4955357.54	362.89	LEROY
687624.94	4951969.86	367.78	MET-C
687377.56	4952448.56	360.24	MET-D
687926.30	4952672.12	365.06	MET-F
687807.82	4952289.82	365.18	MET-G
690591.47	4953418.64	437.29	MET-H
690597.52	4953424.97	434.74	MET-H STAK
687073.24	4951974.56	365.13	PAD3S
680304.90	4949864.88	351.20	PALM PORT
687077.03	4951881.86	365.03	TIPS-BOOM
687079.85	4951898.58	365.30	WES HUT
687083.55	4951896.37	382.57	WES-CAM

Conventional Surveyed Positions

EAST	NORTH	ELEVATION		POINT NAME	
687291.286	4951937.830	354.167	DATALOG		E2
687287.666	4951949.730	354.224	DATALOG	THIRMIST	E2
687287.770	4951950.120	354.221	DATALOG	THIRMIST	E2
687286.786	4951946.670	354.230	DATALOG	THIRMIST	E2
687286.601	4951946.240	354.230	DATALOG	THIRMIST	E2
687285.577	4951947.220	354.240	DATALOG	THIRMIST	E2
687284.793	4951947.040	354.178	DATALOG	THIRMIST	E2
687284.806	4951948.770	354.205	DATALOG	THIRMIST	E2
687285.555	4951949.450	354.188	DATALOG	THIRMIST	E2
687286.265	4951944.930	354.228	DATALOG	THIRMIST	E2
687284.291	4951943.940	354.227	DATALOG	THIRMIST	E2
687284.540	4951942.410	354.248	DATALOG	THIRMIST	E2
687284.123	4951941.970	354.250	DATALOG	THIRMIST	E2
687282.043	4951941.910	354.183	DATALOG	THIRMIST	E2
687281.855	4951940.090	354.178	DATALOG	THIRMIST	E2
687283.104	4951939.210	354.199	DATALOG	THIRMIST	E2
687284.259	4951938.630	354.185	DATALOG	THIRMIST	E2
687282.194	4951937.950	354.175	DATALOG	THIRMIST	E2
687279.550	4951945.630	354.124	MOISTURE	SITE	E2
687280.692	4951928.270	354.026	METTOWER		E2

687271.871	4951930.560	354.077	RAIN	BUCKET	E2
687263.680	4951927.770	354.048	SOIL	MTR	
687284.402	4951964.720	354.107	SOIL	MTR	
687272.148	4951973.160	353.767	METTOWER		E1
687281.141	4951975.890	353.726	RAIN	BUCKET	
687227.221	4951980.790	355.310	DATALOG		E1
687229.229	4951984.980	355.221	DATALOGGER	THERMISTOR	E1
687229.830	4951985.140	355.208	DATALOGGER	THERMISTOR	E1
687230.487	4951985.410	355.190	DATALOGGER	THERMISTOR	E1
687231.101	4951988.560	355.262	DATALOGGER	THERMISTOR	E1
687230.791	4951991.300	355.321	DATALOGGER	THERMISTOR	E1
687230.247	4951991.020	355.262	DATALOGGER	THERMISTOR	E1
687227.370	4951989.650	355.175	DATALOGGER	THERMISTOR	E1
687226.289	4951988.970	355.079	DATALOGGER	THERMISTOR	E1
687227.312	4951988.550	355.156	DATALOGGER	THERMISTOR	E1
687227.439	4951987.640	355.152	DATALOGGER	THERMISTOR	E1
687224.813	4951989.820	355.075	DATALOGGER	THERMISTOR	E1
687226.176	4951986.190	355.121	DATALOGGER	THERMISTOR	E1
687224.415	4951986.510	355.096	DATALOGGER	THERMISTOR	E1
687224.471	4951985.390	355.147	DATALOGGER	THERMISTOR	E1
687223.655	4951984.750	355.165	DATALOGGER	THERMISTOR	E1
687223.420	4951983.580	355.137	DATALOGGER	THERMISTOR	E1
687237.728	4951980.690	355.179	MOISTURE	SITE	E1

687274.621	4952012.430	354.029	ELECTBOX		
687263.332	4952063.950	354.245	ELECTBOX		
687264.687	4952064.040	354.350	TRASFORM		
687348.418	4952006.460	353.737	ROADS000	10METER	
687325.157	4951959.140	354.182	ROADS000	10METER	
687316.301	4951936.920	354.120	ROADS000	10METER	
687084.536	4951895.250	380.152	BUCKET	TRUCK	
687338.461	4952080.470	354.791	METTOWER		
687346.512	4952076.870	354.666	METTOWER		
687340.298	4952076.480	354.665	TOWERANT		
687340.140	4952077.710	354.802	INST	BOX	
687339.665	4952072.450	354.595	VIS	INST	
687336.675	4952068.580	354.613	PROB		
687341.931	4952067.160	354.599	DINT	MTR	
687330.637	4952065.750	354.761	DIR	SOLR	
687329.645	4952063.290	354.725	DIR	SOLR	
687327.995	4952069.220	354.807	MET	SOLR	
687331.572	4952073.010	354.755	RAIN	GAUGE	
687336.854	4952082.710	354.802	RAIN	GAUGE	
687087.218	4951886.280	370.991	ASL	CAMR	
687495.066	4952223.050	354.668	CLOFLINS		
687535.338	4952320.320	355.439	RAILROAD	TRACK	
687492.275	4952349.430	355.404	RAILROAD	TRACK	

687445.311	4952370.770	354.748	ROAD		
687483.553	4952399.640	355.435	ROAD		
687367.325	4952440.180	359.911	STARING	RADIOMETER	D
687355.104	4952445.410	362.232	STARING	RADIOMETER	D
687356.778	4952449.190	362.445	STARING	RADIOMETER	D
687359.104	4952448.180	361.997	STARING	RADIOMETER	D
687361.334	4952448.780	361.900	STARING	RADIOMETER	D
687361.549	4952447.810	361.686	STARING	RADIOMETER	D
687362.544	4952448.300	361.644	STARING	RADIOMETER	D
687362.416	4952450.680	361.955	STARING	RADIOMETER	D
687375.486	4952452.160	360.798	STARING	RADIOMETER	D
687377.705	4952454.880	360.997	STARING	RADIOMETER	D
687379.210	4952458.330	361.324	STARING	RADIOMETER	D
687381.756	4952455.040	360.612	STARING	RADIOMETER	D
687381.999	4952454.850	360.583	STARING	RADIOMETER	D
687382.668	4952452.860	360.287	STARING	RADIOMETER	D
687383.904	4952450.860	359.937	STARING	RADIOMETER	D
687385.075	4952455.110	360.350	STARING	RADIOMETER	D
687383.168	4952458.420	361.004	DATA	LOG	D
687381.058	4952457.340	360.970	SOLR	PNL	
687375.107	4952448.050	360.307	METTOWER	SITE D	
687371.097	4952447.700	360.593	WOOD	BOX	
687363.561	4952446.620	361.085	SOLR	PNL	

687362.611	4952449.650	361.883	DATA	LOG	
687218.218	4952134.510	355.760	TRAILER	CRREL	
687230.949	4952130.920	355.536	TRAILER	CRREL	

Appendix E
Surface Roughness Data

TABLE E1. SURFACE ROUGHNESS DATA SITE 1, E1

14.6	15.1	14.4	15.9	16.2	16.7	17.5	17.0	16.9	17.5
17.1	16.8	18.3	16.6	18.8	17.6	18.5	17.4	18.1	17.9
15.4	17.2	16.2	15.8	17.0	15.3	17.3	13.2	17.6	13.5
12.0	15.4	14.3	14.3	15.1	15.6	16.2	15.2	16.2	15.0
13.5	15.5	15.4	15.8	15.7	16.2	16.5	16.6	16.8	16.5
16.8	15.9	15.8	15.7	15.7	16.0	16.6	16.2	16.7	15.8
16.5	16.0	15.5	14.5	14.4	15.1	15.6	14.8	15.6	14.9
13.8	15.9	13.0	15.0	13.4	12.8	13.2	12.9	13.0	13.5
12.9	12.7	14.8	14.3	14.1	14.0	13.0	11.4	11.3	12.5
14.1	11.3	12.1	11.4	14.3	13.1	13.9	11.1	13.3	11.6

NOTE: Numbers are grand elevations for each 10-cm position within a 1 m by 1 m area.

TABLE E2. SURFACE ROUGHNESS DATA SITE 2, E1

15.6	15.9	17.2	16.9	15.8	15.8	15.1	16.0	15.4	17.0
14.9	15.9	15.5	15.9	14.5	14.4	15.1	18.4	18.0	16.5
15.0	15.4	15.9	15.2	16.0	16.2	18.0	15.9	15.6	17.4
14.1	16.2	15.8	15.9	15.5	15.4	16.0	18.0	15.8	16.6
14.2	16.5	16.5	15.3	15.5	16.4	17.5	16.6	16.0	17.8
12.5	16.5	15.9	15.0	17.0	16.4	16.8	15.0	18.0	17.0
15.6	16.0	16.8	14.2	14.9	16.6	17.9	16.6	16.6	18.4
15.7	16.1	16.2	15.6	17.1	15.6	15.9	18.0	18.5	16.5
15.3	15.9	15.9	15.8	13.4	17.4	15.7	17.4	16.0	16.1
16.7	16.0	15.8	17.2	17.0	13.8	14.6	18.5	18.7	16.4

TABLE E3. SURFACE ROUGHNESS DATA SITE 3, E2

20.4	15.0	10.5	8.3	12.8	13.5	15.3	15.0	17.6	17.0
20.3	16.8	12.1	8.6	10.4	13.8	14.2	14.1	16.3	15.6
20.9	15.5	11.9	8.4	11.1	12.9	14.0	16.0	16.4	16.7
20.8	16.2	12.7	8.2	9.6	12.2	14.4	16.5	16.2	16.0
20.8	15.7	12.6	7.7	4.0	12.1	15.5	16.7	16.4	16.5
20.4	15.6	11.5	7.0	5.8	11.5	14.7	15.5	16.5	16.2
20.3	17.7	12.8	8.5	6.4	8.9	13.4	15.9	16.6	16.4
20.0	18.2	12.8	9.4	7.8	9.4	12.5	15.5	16.2	16.1
20.4	17.8	13.0	10.2	7.1	8.4	11.1	14.8	15.4	15.8
20.6	18.0	13.1	10.9	7.3	9.2	12.6	15.6	15.8	15.5

TABLE E4. SURFACE ROUGHNESS DATA SITE 4, E2

13.9	12.2	13.2	12.3	12.2	12.4	10.7	10.3	10.4	10.5
14.0	13.9	14.4	13.4	13.4	12.9	12.9	12.2	11.5	11.0
15.3	12.3	14.8	15.1	14.6	14.0	12.9	11.8	13.9	12.4
17.0	15.6	15.1	15.5	15.1	15.5	14.4	14.7	14.4	14.5
18.4	15.7	15.7	15.5	16.5	16.0	14.7	14.5	16.3	16.1
18.8	18.9	17.1	17.4	17.6	16.9	16.2	16.2	15.9	16.3
21.2	20.2	19.6	18.5	18.9	17.9	18.2	18.0	17.5	18.1
21.3	21.4	21.1	19.2	19.4	19.4	18.6	19.7	19.6	18.9
21.4	21.4	21.5	19.5	19.8	20.0	19.3	20.1	19.2	20.1
22.3	22.0	21.8	21.8	22.0	20.8	20.7	21.0	21.5	21.3